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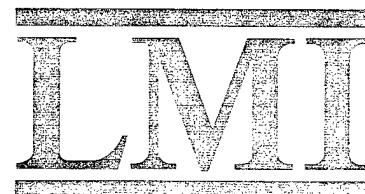
The Depot Repair Cycle Process
Opportunities for Business
Practice Improvement

LG406MR1

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May 1996

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LOGISTICS MANAGEMENT INSTITUTE

The Depot Repair Cycle Process:
Opportunities for Business Practice Improvement

Executive Summary

The depot repair cycle (DRC) begins with a determination that an unserviceable secondary depot-level repairable (DLR) item is beyond the repair capability of an organizational-level or intermediate-level maintenance activity. It ends when the item is restored to serviceable condition and is recorded on the inventory control point (ICP) records. Unserviceable items may remain in storage for extended times before being needed and transferred to depot maintenance. The depot repair cycle time (DRCT) excludes the time in storage.

The overall length of the depot repair cycle is of vital importance to DoD for two basic reasons. First, timely depot repair of failed DLRs is essential to operational readiness and sustainability, and repair is typically the most responsive and least-costly option for supporting customer requirements. Second, because of the high unit cost of DLRs, significant inventory investment results from the length of the depot repair cycle time. Accordingly, the Deputy Under Secretary of Defense (Logistics) asked LMI to study the depot repair cycle process and recommend areas for its improvement.

Our key findings in this study are as follows:

- ◆ Based on the September 1995 *Budget Estimate Submissions*, the dollar-weighted organic/contractor DRCT is 86.8 days, with a resultant repair cycle level investment requirement of \$4.4 billion. That requirement would be decreased an average of \$51 million for each day the DRCT is reduced.
- ◆ Stratification reports indicate that of the \$5.4 billion of assets in maintenance (organic and contractor), \$1.8 billion, or 34 percent, was not needed to meet current requirements, i.e., the amount above the requirement objective.
- ◆ Stratification reports also indicate that of the \$5.6 billion of on-hand unserviceable assets that should be in maintenance to meet current basic requirements, \$2.9 billion, or 53 percent, was not yet inducted. That underinduction includes backorders of \$0.8 billion and safety-level deficits of \$0.9 billion. This is an induction timing issue not a funding issue.
- ◆ The average actual DRCT for a sample of items provided by the Services was 60 days, the ICPs used 57 days to compute the repair cycle level, and the established standard for the sample items was 36 days, or 37 percent less than that used by the inventory control point.

- ◆ Reductions of repair cycle levels, do not result in an immediate proportional decrease in inventory and inventory investment. One-time acquisition and repair savings will be realized over a number of years and will vary by inventory control point, the size of the reduction, the asset position in relation to the requirements, and the mix of serviceable and unserviceable assets. Annual recurring inventory carrying cost reductions associated with the lower inventory will also be realized.
- ◆ The total effect of awaiting parts on the DRC process is not known because its measurement is incomplete and inconsistent. However, considerable partial data indicate that it is a pervasive and serious problem — in one case as much as 12 percent of an annual negotiated program was not completed because parts were not available.

The depot repair cycle is a multifunctional and multiorganizational process. It involves the organizational-level and intermediate-level maintenance and supply activities, transportation, distribution depots, inventory control points managing DLRs and those managing repair parts, depot maintenance activities, and supply activities supporting depot maintenance. Improvements to the repair process, therefore, must address the roles and interfaces among all functions and activities.

We recommend that the Deputy Under Secretary of Defense (Logistics) take the following actions to improve the DRC process business practices:

- ◆ Current business practices, especially production planning and induction processing, are major contributors to the multibillion dollar maintenance imbalance, the excessive elapsed actual maintenance shop time, and large in-process inventory. To redress both the imbalance of inductions and requirements and the disparity between actual and standard DRC times,

Make the objective of production planning the determination of how the total depot maintenance requirement can be accomplished (capability), and

Revise the induction process and the use of repair workorders authorizing depot-level maintenance by increasing frequency, limiting funding and quantities to bi-weekly cycles, and using current asset data to determine those quantities. Details of these recommendations are contained in Appendix A.

- ◆ The present DoD policy of using actual DRCTs for requirement computations results in excessive inventory investment and DRCTs. To reduce investment and improve responsiveness,

Revise current policies to require establishment of standards for each DRC segment as proposed in Appendix A and require their use in requirement computations, budget submissions, the repair process, and performance evaluation, and

Establish performance measurement and reporting requirements to collect and compare actual and standard DRCT by segment.

- ◆ Awaiting parts time adversely affects the maintenance process by necessitating the rescheduling of production and increasing the labor hours and costs. Those actions cause production inefficiencies and delay customer support. To minimize that impact,

Improve the process of recording piece-part consumption and forecasting parts requirements, including the use of bill-of-material concepts. Consider revising the methodology for computing depot maintenance requirements starting with a zero base and computation based on production plans and bills of material.

- ◆ Many of the “best practices” receiving major emphasis from *Industry Week’s 25 finalists for America’s 10 Best Plants* are germane to improving the depot repair cycle business practices and are consistent with the recommendations of this report. To exploit the benefits of those private-sector practices,

Adopt the appropriate private-sector best practices as principles for improving the DRC business processes.

- ◆ The current DRC segments and definitions do not provide a complete framework for improving the repair process and for establishing standards. To reduce the repair cycle level and related \$4.4 billion inventory investment, to establish a ceiling on assets undergoing repair, to provide for economic induction quantities, and to ensure an effective process framework,

Consider revising DoD Regulation 4140.1-R, DoD Materiel Management Regulation, to incorporate DRC definitions as proposed in Appendix A. For those accepted, require their use in requirement computations, budget submissions, the repair process, and performance evaluation.

- ◆ Other recommendations include the following:
 - ▶ *Require that items in a critical asset position be automatically returned, expeditiously processed, and express transportation used when appropriate.*
 - ▶ *Provide inventory control points with improved materiel management systems to generate repair workorders on a more frequent cycle using current assets. Provide depot maintenance with finite capacity scheduling and Material Resources Planning II systems enabling them to respond quickly to changing customer needs and to “de-induct” quantities in excess of current requirements.*
 - ▶ *Evaluate depot maintenance performance (organic and contractor) based on time standards and on-time delivery. Evaluate inventory control point performance based on parts and carcass shortages and validity of repair production requirement forecasts.*
- ◆ The findings and recommendations of this report affect many activities and functions encompassed by the DRC process and interfaces among them. At the same time, those processes are undergoing major changes as the Military Services and DLA implement business process re-engineering along with

the development of new information management systems. To ensure that the near-term efforts are fully coordinated for effective, progressive, and timely implementation of the improved business practices,

Establish a DoD Depot Repair Cycle Integrated Process Team including representatives from the Army, Navy, Air Force, Marine Corps, and the Defense Logistics Agency, to develop a prioritized schedule of improvements and to monitor and report on their status.

We believe that collectively the recommended changes will substantially reduce the actual DRCT, will cut the RCL inventory investment requirement, will minimize the over-induction and under-induction, and will materially increase the flexibility and responsiveness of today's DLR depot repair process.

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CHAPTER 1

Major Findings, Conclusions, and Recommendations

INTRODUCTION

Background

Department of Defense (DoD) Regulation 4140.1-R, *DoD Materiel Management Regulation*, defines the depot repair cycle (DRC) for secondary depot-level reparables (DLRs) as beginning with determination that an unserviceable item is beyond the repair capability of an organizational- or intermediate-level maintenance activity. It ends when the failed item is restored to serviceable condition and recorded as such on supply records. Excluded from this DRC definition are any awaiting parts delays and any intentional extended transit, storage, or repair process delays. The depot repair cycle time (DRCT) is normally measured in elapsed calendar days.

The overall length, or duration, of DRC is of vital importance to DoD for two basic reasons. First, timely depot repair of failed repairable components is essential to operational readiness and sustainability. For these key reparables, depot repair (by organic or commercial sources) is typically the most responsive and least costly option available to support the operating customers' requirements. Second, because of the high unit cost of repairable components, significant inventory investment results from the length of the DRCT. The quantity of wholesale repairable items required to sustain operations during this period is referred to as the repair cycle level (RCL). That level represents the demand (constrained by unserviceable returns) for the item that can be expected during the DRC. The shorter the DRCT, the smaller the investment in the RCL.

The DRC is a multifunctional and multiorganizational process. It involves the organizational- and intermediate-level maintenance and supply activities, transportation, distribution depots, inventory control points (ICPs) managing DLRs, ICPs managing repair parts, depot maintenance activities (organic and contractor), and installation supply activities supporting depot maintenance. Improvements to the depot repair cycle process, therefore, need to address the roles and interfaces among all those functions and activities.

The DoD wholesale inventory investment in DLR assets was \$38.1 billion as of September 1994 (*Supply System Inventory Report* — reduced prices).

Table 1-1 displays the overall magnitude of the DRC in terms of days and dollars and is based on the September 1995 *Budget Estimate Submission* (BES).

Table 1-1.
Dimensions of DoD Depot Repair Cycle — FY95
(\\$ millions — at standard price)

Reparables items managed	352,022
Repair cycle times (calendar days)	86.8
Repair cycle level requirement	\$4,424.6
Average value of a repair cycle day	\$51.0

Study Objectives

In this study, the Logistics Management Institute (LMI) analyzes the depot repair cycle process to determine whether DoD can provide more responsive customer support at a lower cost. Organic and contractor repair processes are included; however, the unique aspects of contractor repair will be the subject of a separate LMI study. The analyses in this report are focused on four major areas:

- ◆ The definitions of the DRC segments — the segments that are major contributors to the total DRCT and have the greatest potential for improvement — the establishment of “should-take” time standards, the potential for reducing inventory investment, and the potential for establishing performance measures.
- ◆ The effectiveness of repair programming, production planning, and induction processing in providing to the supply system serviceable assets of the right item, in the required amount, and at just the right time.
- ◆ The effect of unanticipated delays (awaiting parts [AWP], awaiting carcasses [AWC], and awaiting maintenance [AWM] capacity) that are not supposed to be a part of the DRC but adversely affect responsiveness and costs.
- ◆ The system and procedural deficiencies and the changes to them that are essential to the implementation of the recommended improvements necessary to make the process more responsive and less costly.

Study Approach

Our review of the DoD DRC process includes analyses of available empirical data (reflected in secondary item stratification budget summaries, ICP inventory management files, depot maintenance files, and sample items selected by the ICPs we visited); review of existing policy, procedural, and system documentation; and site visits/interviews at selected headquarters and at two ICPs and two depot maintenance activities each of the Army, Navy, and Air Force.

Our major findings, conclusions, and recommendations relate to

- ◆ the process of developing production plans and the process of authorizing and funding the repair of materiel and its induction into maintenance;
- ◆ the segments of the DRC, their definitions, and the establishment and use of time standards;
- ◆ the effects of unanticipated delays, especially those AWP, and their accommodation in requirement computations; and
- ◆ the accumulation of actual elapsed time by DRC segment, the comparison of actual times with standard times, and the generation of performance reports for management.

More detailed discussions of these and additional issues and more specific recommendations are presented in Chapters 2 through 5 and Appendix A, "Detailed Depot Repair Cycle Business Practice Improvements." Many of our recommendations parallel those cited as the private-sector "best practices" in a 1994 *Industry Week* issue that presented the 25 finalists and nominations of "America's 10 best plants." In Appendix A, we also describe those private-sector best practices that are germane to the DRC process.

Current Initiatives

The research for this task was conducted at a specific point in time. Prior to and subsequent to that time, each of the Military Services and DLA developed materiel management initiatives that included improvements to the DRC processes.

The Army, under its *velocity management* program, has developed initiatives covering several of the areas addressed in this report. Similarly, the Air Force under its *lean logistics program*, has implemented some highly innovative process improvements. The Navy made changes that reduce the DRCT and provide reports that permit better evaluation of the DRC processes and identify potential problem areas. While it does not manage DLRs, the Defense Logistics Agency (DLA) is the major supplier of piece parts and has, in coordination with the Services, implemented changes to improve parts support and stock positioning.

PRODUCTION PLANNING AND THE INDUCTION PROCESS

Findings

- ◆ Under current DoD policies, procedures, processes, and management information systems used to control and monitor the depot repair process, maintenance inducts assets not currently required for some items and does not

induct assets that are required for other items. As shown in Figure 1-1¹ 34 percent of the total assets in maintenance (\$5.4 billion) is not required to meet current known stratification requirements. The reports also indicate that of the approximately \$5.6 billion in unserviceable assets currently on hand that should be in maintenance to meet current basic requirements, 53 percent (\$2.9 billion) was not yet inducted. This underinduction includes backorders of \$0.8 billion and safety-level deficits of \$0.9 billion.

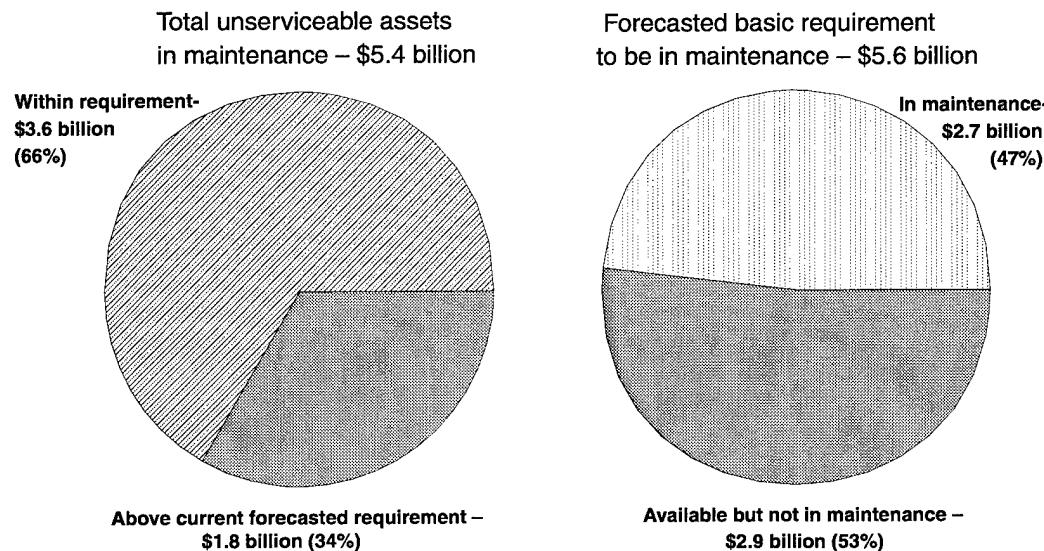


Figure 1-1.
Early/Late Inductions

- ◆ Generally production planning, funding, and the authorization of repair come from the same processes. They cover from one to four quarters based on asset position data that may be from six to nine months old at the time of induction and with requirements frequently based on annual quantities leveled by quarter. The production planning process includes negotiations — usually downward and smoothed over time — between the maintenance activities and the ICPs.
- ◆ Although actual repair requirements change daily, the negotiated schedule is then accepted for the next quarter, two quarters, or year. Once assets are physically inducted for repair, they are seldom, if ever, withdrawn. Some changes occur for high-priority requisitions but very little based on supply position (i.e., changes in requirements or assets).

¹The values are at standard price and taken from Budget Opening Position of Table I of the 31 March 1995 stratification reports. "Above current forecasted requirements" is defined as exceeding the requirements objective. "Forecasted basic requirement to be in maintenance" is defined as demand-based requirements up to and including the RCL but excluding other war reserves and the numeric stockage objective (NSO).

- ◆ Generally the induction quantity, timing, and frequency are controlled by maintenance within the quarterly or longer funded authorizations.
- ◆ The sample items included many examples of inductions that exceeded the asset deficit, exceeded the total recurring and nonrecurring demand, and/or exceeded the maintenance production rate. Those inductions resulted in larger than necessary in-process inventory and actual DRCTs longer than the standards.

Conclusions

PRODUCTION PLANNING

- ◆ The objective of production planning should be to determine *how* depot maintenance activities can ensure having adequate capability (overtime, extra shifts, temporary employees, cross-training or subcontracting) to complete on time the entire forecasted DLR workload (repair for stock, concurrent repair for overhaul, inter-Service support, and foreign military support) and an agreed-upon upward variance rather than negotiating the workload down to the normal capacity.
- ◆ Production planning based on annual averages will not provide the capability required for timely completion of a workload that ranges from items with backorders and safety-level deficiencies requiring very high initial "catch-up" production to items in long supply of serviceable assets that may not require initial small inductions until the 3rd or 4th quarter.

INDUCTION PROCESSING

- ◆ The frequency that imbalances between *materiel that is in maintenance and that which should be in maintenance* occurred in the sample items, and their magnitudes reflected in the summary data are too great to result solely from changes in requirements and assets, i.e., churn. They indicate systemic problems and a need for business practice improvements.
- ◆ Many of the scheduling deficiencies observed (early/overinduction and late/underinduction) were directly or indirectly a result of practices that essentially used mid-term production planning projections based on relatively old requirement and asset data as the basis for funding and authorizing maintenance to induct one or more quarters of requirements.
- ◆ To minimize in-process inventory and actual elapsed DRCT and to provide flexibility in meeting the fluctuating and changing requirements reflected in more frequent workorders for smaller quantities
 - ICPs need automated ordering systems utilizing current information, and

- depot maintenance activities need automated scheduling and control systems such as finite capacity scheduling and Manufacturing Resources Planning (MRP) II.

Recommendations

The major process change is the uncoupling of workorders, funding, and induction authorization from the production planning process (more detailed process improvements are presented in Chapter 3 and Appendix A). We believe that collectively the changes recommended in production planning and induction processing, including funding, will substantially reduce actual DRCT, will decrease RCL inventory/investment requirements, will minimize the imbalance of overinduction and underinduction, and will materially increase the flexibility and responsiveness of today's depot repair process for DLRs in meeting customer needs.

We recommend that the Deputy Under Secretary of Defense (Logistics) take the following actions.

PRODUCTION PLANNING

- ◆ Reorient production planning with the objective of determining *how* the forecasted workload can be completed (overtime, extra shifts, temporary employees, or cross-training subcontracting). That fundamental change from the current practice of adjusting repair requirements to match normal maintenance capacity represents a challenge.
- ◆ Predicate production planning on the premise of providing flexibility to complete the repair of fluctuating item requirements with a goal of on-time (elapsed time based on standards) processing of repair workorders varying by an agreed-upon percentage above the forecasted item workload without further negotiation.
- ◆ Develop as a minimum an annual plan with variable monthly requirements and three quarterly updates for the 2nd, 3rd, and 4th quarters, using the most current asset data for all items. The plans should provide variable monthly estimates and be coordinated and distributed 45 days before the beginning of the period. Plans should include piece part requirement forecasts.

INDUCTION PROCESSING

- ◆ Uncouple the induction process from production planning.
- ◆ Provide ICPs with the capability to execute repair authorization and funding on a maximum biweekly cyclic basis with workorders generated the

standard lead-time for the item in advance of the required date for the serviceable assets using requirement and asset data as of the cutoff.

- ◆ Have ICPs transmit workorders electronically directly to the depot maintenance activity with automatic acceptance of orders that do not exceed the forecasted requirements by more than the agreed-upon percentage for an item. Have maintenance activities limit induction to economic quantities within the biweekly authorizations and deliver serviceable assets incrementally.
- ◆ Provide depot maintenance activities with automated systems, such as finite capacity scheduling and MRP II, to provide the capability and flexibility required to react to smaller and more frequently funded repair orders reflecting variable requirements and priorities and shorter required dates.

DEPOT REPAIR CYCLE SEGMENTS AND TIME STANDARDS

To establish uniform elements for managing and measuring DRC, DoD defines five discreet segments. The current policy in DoD Regulation 4140.1-R states that the Services will use *actual* repair cycle times in computing the RCL.

Findings

- ◆ DRCT is inconsistently defined and measured across the Services. The incorporation of DoD-prescribed elements varies widely by Service, as does the mix of actual time, constrained actual time, estimated times, and standard times in the ICP files.
- ◆ In the aggregate, the current BES-based DRCT for DoD averages about 87 days with an associated RCL inventory investment of about \$4.4 billion as shown in Table 1-1. That total DoD RCL inventory requirement would be decreased an average of \$51 million for each day the DRCT is reduced.
- ◆ Figure 1-2 compares the actual DRCTs and the ICP file DRCTs with the standards for the sample items combined from the three Services. Actual DRCTs exceed those used by the ICPs to compute RCLs and are significantly longer than reasonable “should take” standard DRCTs.

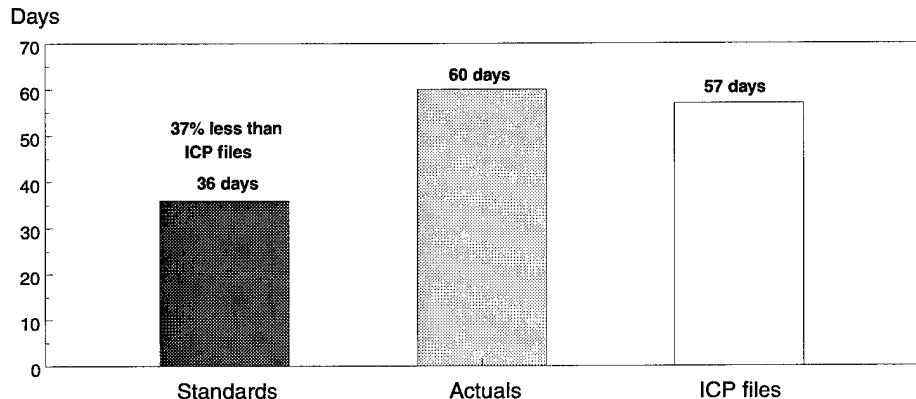


Figure 1-2.
Sample DoD DRCT Standards, Actuals, and ICP Files

- ◆ Use of the standards to compute the RCLs for the sample items would result in a 37 percent reduction in the RCL value. Applying that difference reflected in the sample to the total RCL value of \$4.4 billion shown in Table 1-1 would produce a \$1.6 billion reduction.
- ◆ Computing the RCL on the basis of standards does not produce an immediate proportional reduction in inventory investment. The rate of investment reduction is dependent upon the relationship of assets to requirements and upon the mix of serviceable and unserviceable assets.

Conclusions

- ◆ Inventory managers (IMs) do not have enough data to establish DRC times and the current DoD policy of using actual times is causing increased inventory investment and impeding the timely repair of DLRs.
- ◆ Use of standards as valid benchmarks in requirements computation, budgeting, and repair execution would focus the attention of both supply and maintenance management on DRCT. Thus, the cost and ultimate support effectiveness of the depot repair processes would be directly driven by the validity of, and the use and adherence to, these standards.
- ◆ The *actual elapsed* repair turnaround time (RTAT), the *file time* used to compute the RCL, and the *RTAT standard* must have a high degree of consistency to minimize inventory investment, provide optimum assets to sustain issues during the repair process, and provide a reliable basis for generating repair workorders and required dates.
- ◆ Reduction in RCLs provides the opportunity for inventory investment reductions and for one-time reductions in procurement and repair

requirements. However, reductions do not result in an immediate proportional decrease in inventory investment.

- Savings will be realized over a number of years varying by ICP and depending on the size of the reduction, the asset position in relation to the requirements, and the mix of serviceable and unserviceable assets.
- Based on total data for two ICPs, only approximately one-eighth of the potential acquisition savings and one-third of the potential repair savings would be realized at the end of six years.
- ◆ The current DRC segments and definitions should be revised as proposed in Appendix A to provide the necessary framework for improving the repair process and for establishing time standards.

Recommendations

To reduce the repair cycle level and the related \$4.4 billion inventory investment and to provide the framework for improving the depot repair process by establishing a ceiling on assets undergoing repair, providing for economic induction quantities, establishing a biweekly repair order cycle, and recognizing the need for repair administrative lead-time to generate and process workorders, we recommend that the Deputy Under Secretary of Defense (Logistics) take the following actions:

- ◆ After coordination with the DoD Components, publish changes to DoD Regulation 4140.1-R to incorporate the revised DRC definitions and segments and to establish standards for each as proposed in Table A-1 of Appendix A. Require their use in requirement computations, budget submissions, the repair process, and performance evaluations.
- ◆ Develop a schedule for implementing the changes and a transition plan with goals for reducing the current RCLs to the prescribed standards and for subsequently reducing inventory investment.

UNANTICIPATED DELAYS

Findings

In concert with the move toward use of DRCT standards, maintenance management information systems and the requirements determination processes in place at Service ICPs must address the major unanticipated delays that are likely to occur during the repair process and that are neither authorized to be a part of the current DRCT nor included in the proposed standards.

- ◆ The three types of major unanticipated delays that must be considered are
 - ▶ awaiting parts (AWP), which occurs when the nonavailability of parts results in delayed production;
 - ▶ awaiting carcasses (AWC), which occurs when the lack of availability of unserviceable assets results in delayed production; and
 - ▶ awaiting maintenance (AWM), which occurs when capacity constraints results in delayed production.
- ◆ Data from one maintenance depot indicate that delays for parts, carcasses, and maintenance capacity jointly accounted for over 6 percent “underproduction” (the actual repair volume was less than the planned repair volume) in FY94. That does not take into account production delays during the year.
- ◆ Of a sample of 365 national stock number (NSN) items causing AWP delays at one depot, approximately 75 percent experienced work stoppage or required workarounds of between 30 days and 574 days as of the report cut-off. The shortage quantities ranged from 1 to 5,324 units.
- ◆ The lack of low-cost piece parts delay the repair of high-value components. For example, a bearing caused a work stoppage on a cylinder assembly for over 440 days as of the report cut off, and that delay was expected to increase. The value of the 279 bearings in the assembly was \$5,178 and the value of the 70 DLRs involved was \$3,272,640, or 632 times the value of the parts causing the work stoppage.

Conclusions

- ◆ Current systems at the wholesale supply or depot maintenance level do not provide a comprehensive view of the frequency, duration, magnitude, or adverse impacts of unanticipated delays.
- ◆ AWP clearly has a major adverse effect on the repair process.
- ◆ When they occur, each of the three unanticipated delay factors affect the length of the time required to produce a serviceable asset. By properly accounting for unanticipated delays separately, performance evaluation and analysis of major contributors to differences between DRCT standards and the actual DRCTs can be accomplished. Failure to properly recognize and adjust for these unanticipated delays will undermine the use of DRCT standards and has the potential to degrade responsive support.

Recommendations

To minimize the adverse effects of unanticipated delays, including rescheduling production and increasing labor hours and costs, production inefficiencies, and delays in customer support, we recommend that the Deputy Under Secretary of Defense (Logistics) take the following actions:

- ◆ Improve management information systems to measure the frequency and duration of each type of unanticipated delay to identify problem areas requiring management attention and collect enough information to compute the variance in those delays. Continue to exclude unanticipated delays from the DRCT.
- ◆ Use the computed variances in repair processing caused by unanticipated delay factors to compute the wholesale repair safety-level requirement.
- ◆ Because the investment in parts is small compared with the cost of the DLR items and lost productivity, implement the specific process improvements recommended in Chapter 4 to reduce AWP. Those improvements include improving parts consumption data, revising wholesale parts forecasting methodology, and reviewing stockage policies for activities that provide supply support to maintenance.
- ◆ Minimize carcass shortages by directing automatic and expedited return of items in a critical supply position.

PERFORMANCE REPORTING

Findings

A noteworthy and desirable contrast is apparent between intermediate-level maintenance and depot-level maintenance in the availability of repair process data and in the respective management uses of those data.

- ◆ Each of the Services' intermediate-level maintenance systems can record, by individual workorder, the beginning and ending of delays. Each begins recording AWP immediately upon notification of the nonavailability of parts (no minimum forecasted delay). Those records also display requisitions for parts and their status. Management reports show the work in process by time periods and all delays.
- ◆ At the wholesale level, the Services do not have systems for routinely measuring and comparing line-item standard, actual, and ICP file DRCTs, which vary significantly, or for generating management reports to permit evaluating and improving the repair process.

Conclusions

- ◆ The Services do not evaluate the storage depot or depot maintenance performance on the basis of actual elapsed times compared with standards or required dates, nor do they evaluate ICP performance on the basis of parts or carcass shortages.
- ◆ With the adoption of DRCT standards for wholesale requirements determination, induction scheduling, and DLR repair execution, supply and maintenance managers need to measure the actual elapsed DRCT and be able to take corrective action for significant delays or differences between it and the standards.

Recommendations

To provide the means to evaluate the performance of the repair process in producing the right item, in the right quantity, and at the right time, we recommend that the Deputy Under Secretary of Defense (Logistics) take the following actions:

- ◆ Establish performance measurement and reporting systems to collect and compare actual and standard DRCT, to measure the total elapsed repair process time by item, and account separately for the actual time for each prescribed segment and for each of the unanticipated delays; furthermore, the performance systems should
 - ▶ generate reports that compare, by segment, the approved standard and the required delivery date with the actual times and that accumulate the actual time for each of the unanticipated delays; and
 - ▶ use the unanticipated delay data to compute safety levels and to determine the need for process improvements.
- ◆ In addition to the current evaluation based on efficiency, evaluate the performance of depot maintenance activities (organic and contractor) on the basis of a comparison of actual and standard maintenance shop times and the on-time completion of the total maintenance workload.
- ◆ Evaluate the performance of the ICPs on the basis of DLR repair delays caused by parts shortages, carcass shortages, and the validity of the repair production requirement forecasts.

IMPLEMENTATION

Introduction

MID-TERM ACTIONS

Complete implementation of some of the major recommendations to improve the depot repair cycle business practices require substantial information system changes at the ICPs and at the maintenance depots. Development and installation of those changes require time.

To begin the processes for making those changes, we recommend that the Deputy Under Secretary of Defense (Logistics) take the following actions:

- ◆ Evaluate the recommendations contained in Chapters 2 through 5 and Appendix A of this report
- ◆ Determine what policy changes are needed
- ◆ Publish those changes with an implementation schedule as mid-term planning guidance for the DoD Components.

NEAR-TERM ACTIONS

In the near term, DoD should take a series of actions to implement improvements incrementally. Those actions should be aimed at decreasing the imbalance between the DLRs that are in maintenance beyond current requirements (\$1.8 billion) and those that should be in maintenance but have not yet been inducted (\$2.9 billion), reducing the 87-day DRCT that drives the RCL inventory investment of \$4.4 billion and enhancing customer response (\$0.8 billion in backorders).

The specific actions that can be taken and the time frames for their implementation will vary by DoD Component and will be based on existing systems, changes already in process, the acquisition of new capabilities such as finite capacity scheduling and MRP II, and interfaces among functional areas.

We further recommend that the Deputy Under Secretary of Defense (Logistics) request each DoD Component to provide an action plan and schedule for implementing progressive near-term improvements leading to the end objective.

INTEGRATED PROCESS TEAM

The findings and recommendations in this report affect varied activities and functions encompassed by the DRC processes and interfaces among them. At the same time, these processes are undergoing changes as the result of DoD

Component improvement programs along with the development of materiel management systems.

To ensure that the total near-term and mid-term effort is fully coordinated for effective and timely implementation of the improved business practices, we recommend that the Deputy Under Secretary of Defense (Logistics) should establish a DoD Depot Repair Cycle Integrated Process Team composed of representatives from the Army, Navy, Air Force, Marine Corps, DLA, and the Joint Logistics Systems Command. That team should be responsible for the following activities:

- ◆ Reviewing the recommendations of this report
- ◆ Proposing a schedule of near-term actions (those actions will vary by DoD Component)
- ◆ Recommending priorities for and a schedule of mid-term changes
- ◆ Monitoring and reporting results.

Progressive Improvement

In this subsection, we describe some of the incremental improvements that should be implemented in the near term in order to meet the overall objectives.

INDUCTION PROCESSING

The single most important change that addresses both the imbalance of inductions and requirements and the disparity between the actual and standard DRCTs is the revision of repair workorders authorizing depot-level maintenance to perform repair (increasing frequency, limiting funding and quantities to bi-weekly cycles, and using current asset data to determine those quantities). That change should mandate that supply and maintenance do the following:

- ◆ Move from the current 3- to 6-month induction funding and authorization period toward a biweekly period. That action may require phasing.
 - ▶ As a minimum, determine the feasibility of running existing quarterly programs monthly with current asset data to generate monthly funded workorders.
 - ▶ Preferably review current weekly and biweekly tools for possible modifications, including the application of those tools to all items requiring repair and the use of the current asset position.

USE DRCT STANDARDS FOR COMPUTING REPAIR CYCLE LEVELS

The use of RTAT standards (engineered and allowances) in lieu of actual or IM-determined times offers the potential for reducing the RCLs. The conversion to standard times requires that the average actual production be completed within those standard time frames and that actions by the ICPs and the depot maintenance activities be closely coordinated.

- ◆ Those Services that have maintenance shop standards expressed in calendar days and are not using them for RCL computations should provide those data to the ICPs:
 - ▶ ICPs should develop RTATs using the maintenance shop standards and the proposed standard allowances for storage-to-maintenance and maintenance-to-storage time segments.
 - ▶ Until smaller repair workorders based on current asset data have reduced backlogs in maintenance, the difference between the existing ICP file DRCTs and those based on standards may have to be reduced incrementally.
- ◆ Those Services that do not have maintenance shop standards but do have labor-hour standards or historical actual hands-on hours for pricing purposes could develop interim proxy standards by developing ranges of labor hours and applying additives to cover non-labor-hour processes (e.g., drying), queue time before and after each process, and moving time from workstation to workstation (normally those additives decrease with the increase in the number of labor hours). They could then
 - ▶ convert the productive labor hours to calendar days, and
 - ▶ provide the proxy standards to the ICPs for development of RTATs by adding standard allowances for transfer to and from maintenance.
- ◆ Those Services that do not have engineered maintenance shop standards should initiate a program to develop them.

DEVELOP DRCT PERFORMANCE MEASUREMENT AND EVALUATION

One requisite of a successful DLR repair process is the achievement of minimal variance between the RTAT portion of the DRCT used by the ICPs to compute the RCL and the actual time taken by storage and maintenance for that segment and its time standards. Neither the maintenance activities nor the ICPs

have routine management reports providing those comparisons to permit measurement and evaluation of this critical management performance indicator. We recommend the following actions:

- ◆ Those Services that have both the standard and actual RTATs should develop interim reports comparing those times and highlight the ones with high variances.
- ◆ All Service stock accounting systems should capture the transactions changing items from Condition Codes F to M and M to A.
 - ▶ As a interim measurement of the total RTAT, those transactions should be used to develop the actual RTATs and be provided to the ICP and to the maintenance depot. ICPs should supplement the actual data with their file times for comparison.
 - ▶ Both maintenance and the ICPs should establish thresholds for actual RTATs and jointly examine those items that exceed the thresholds to determine what actions should be taken to reduce the actual time to an acceptable level.

CHAPTER 2

Depot Repair Cycle Segments, Times, and Performance Measurement

INTRODUCTION

The amount of elapsed time during which an asset is in the depot-level repair cycle — the depot repair cycle time — is significant because additional assets must be procured to support operations while unserviceable assets are in the cycle undergoing repair. The longer the DRCT, the more assets needed in the supply system to ensure that operations are not interrupted while waiting for unserviceable DLRs to be fixed.

DEPOT REPAIR CYCLE SEGMENTS

Current Policies and Practices

DoD POLICIES

To establish uniform elements for managing and measuring the DRC, DoD policy identifies and defines five discrete segments: retrograde (includes base processing and in transit), accumulation, transfer to maintenance, depot maintenance turnaround, and transfer from maintenance. These terms are defined in DoD Regulation 4140.1-R. We use the term *repair turnaround time (RTAT)* as a collective term for transfer-to-maintenance time, depot maintenance turnaround time, and transfer-from-maintenance time. We also use the term *maintenance shop time* in lieu of depot maintenance turnaround time.

CURRENT PRACTICES

As shown in Table 2-1, the DRC segments are not consistently applied across the Services. None of the Services uses all five of the prescribed DoD segments; all exclude accumulation time. The Air Force alone uses the retrograde segment and divides it into base-processing time and in-transit time. While the Air Force recognizes the transfer-to-maintenance segment, it allows zero days in its standard. The Services' definitions of the segments they use follow the DoD definitions, but only the Air Force separately identifies each segment in its requirement studies. The Army and Navy display only the total RTAT segment.

Table 2-1.
Depot Repair Cycle Segment Use by Service

Segment	Army	Navy	Air Force
Retrograde — Base processing — in transit	No No	No No	Yes Yes
Accumulation	No	No	No
Transfer-to-maintenance	No ^a	No ^a	Yes ^b
Depot maintenance turnaround	No ^a	No ^a	Yes
Transfer-from-maintenance	No ^a	No ^a	Yes

^aThe Army and the Navy record transfer to maintenance, depot maintenance turnaround, and transfer from maintenance as a single entity.

^bThe Air Force recognizes the segment but by policy allows no time in the standard.

Evaluation

Based on our evaluation of the current DoD segments and definitions, we draw the following conclusions:

- ◆ The current RCL is defective in that it only establishes the minimum number of assets that should be on hand, either serviceable or in maintenance, and does not establish any ceiling or maximum. It implies the need for daily inductions equal to the daily issues. That implication fails to give maintenance any lead-time for planning its daily production or for evening out the daily fluctuations in returns or ordering parts and unserviceable assets.
- ◆ The current accumulation segment is neither needed nor used by any of the Services.
- ◆ Since the base-processing and in-transit segments are under completely separate functional control, they should be separate segments.
- ◆ The current DRC segments and definitions do not provide the necessary framework for improving the repair process and for time standards.

Process Improvement

To ensure an effective framework for improving the depot repair process, we recommend that the Deputy Under Secretary of Defense (Logistics) revise DoD 4140.1-R to reflect the segments that comprise the DRC and their definitions

similar to those proposed in Appendix A. It includes the following key process improvements:

- ◆ Establishment of a biweekly repair workorder cycle (similar to the procurement cycle).
- ◆ Recognition of the need for repair administrative lead-time to generate and process workorders and schedule production.
- ◆ Establishment of the maximum quantity that should be in maintenance.

DEPOT REPAIR CYCLE TIME ALLOWANCES

DoD Policy

DoD 4140.1-R states that *actual* repair cycle times will be used by the Services in computing RCL requirements. It requires that all the time between the beginning and end of the repair cycle be included in computing RCL requirements, except avoidable time, such as that expended while AWPs or because of depot maintenance inefficiency. Accumulation time is constrained by policy to a maximum of seven days. The policy reiterates the time spent awaiting parts will *not* be included in repair cycle computations.

Current Practices

In this report, we use the generic term *standards* to include three types of engineered standards and standard allowances established by policy.

Computation and application of DRCTs in requirements computations differ across the Services. They range from actual or historical, engineered standard times, standard allowances, and judgment. The Army formerly used historical averages (the data are not currently available) and the Navy uses exponentially smoothed times. Both are subject to modification by the IM. The Air Force uses standards and standard allowances (including constrained actuals for in-transit time) in requirements determination, budgeting, and execution. It is the only Service that provides line-item data for each segment of DRCT in the requirements determination system.

The most extensive use of standards is in the development of maintenance depot labor costs and repair prices charged to customers. Often they are not used to establish maintenance shop total elapsed time standards.

The Air Force maintains shop flow time standards and expresses them in elapsed calendar days; those standards include additional factors such as non-productive time and moving, queuing, and setup times. About 45 percent of the Air Force DLRs do not have individual repair cycle standards but use a

surrogate standard based on the average of all items with standards. Included in the items with standards are most contractor-repaired items for which the contract delivery period has been used (usually 30, 60, 90 days, etc.) as the time standard. These times, which are not engineered standards, increase the average surrogate standard used for 45 percent of the items without standards. A recent Air Force study concluded that eliminating the contractor-repaired items from the computation would reduce the average from around 29 days to 15 days.¹

The establishment of valid maintenance shop and RTAT standards is a prerequisite to the successful operation of finite capacity scheduling MRP II, and similar systems for scheduling repair production and ordering materiel.

Evaluation

COMPARISON OF STANDARD, ACTUAL, AND ICP FILE RTATs

The comparison of standard, actual, and ICP file RTATs is difficult because the Services do not have systems for capturing and comparing the times. Therefore, we compared data for sample items provided by the ICPs using a combination of ICP data and manual depot records. We evaluated three different measures of RTAT: standard or "should take" time, actual time based upon historical transactions, and the times resident in the ICP files used to compute the RCL requirement. Because the Air Force alone uses RTAT standards for budget and execution, we derived comparable standards for the Army and Navy.

As Table 2-2 illustrates, the standard ("should take") times differ from the actual time and the ICP file time used to calculate requirements.

Table 2-2.
*Comparison of Standard, Actual, and ICP File RTATs
 (in dollar-weighted days)*

Service	Standard RTAT (Days)	Actual RTAT		ICP file RTAT	
		Days	Percentage above standard	Days	Percentage above standard
Army	81	180	122	147	81
Navy	32	38	19	45	41
Air Force	20	42	110	20	0

The Army data indicate that the sample actual times are more than twice the standard times. While the ICP file times are lower than the actuals, they exceed

¹Captain Bradley D. Silver et al., *Analysis of the Depot Repair Process*, Air Force Logistics Management Agency Report 93-26697, July 1993.

the standards by 81 percent. Consequently, the Army's inventory investment for the sample items is 81 percent greater than it would be if standards were used.

The Navy data indicate that sample actual times are only 19 percent greater than the standard times. However, the ICP file times are greater than either the standard or actual times resulting in a 41 percent increase in inventory investment for the sample compared to the use of standards.

The Air Force data indicate that the sample actual times are more than twice the standard times. The Air Force uses the standards in the computation of the RCL and therefore the longer actual times do not increase the inventory investment for the sample items but do affect the availability of serviceable assets.

Two types of one-time savings can occur as a result of reducing the RCL. First, a one-time postponement of repair will occur when serviceable assets fall below the prior RCL. Second, a one-time postponement of procurement will occur when the combined serviceable and unserviceable assets fall below the prior reorder point. Based on the asset position of all DLR items for two sample ICPs, Table 2-3 displays by year the percentage of the RCL reduction that would produce inventory investment savings assuming that the change occurred on the first day of year 1. The actual savings will vary by ICP based upon the magnitude of the RCL reduction as well as the asset mix and position. For the sample, only approximately one-eighth of the potential acquisition savings and one-third of the potential repair savings would be realized at the end of six years.

Table 2-3.
Realizing Savings from RCL Reduction — Two Sample ICPs

Year	Acquisition (percentage)		Depot repair (percentage)	
	Annual	Cumulative	Annual	Cumulative
1	3.40	3.40	3.61	3.61
2	0.13	3.53	2.52	6.13
3	1.98	5.51	1.47	7.60
4	6.45	11.96	10.6	18.2
5	0.75	12.71	8.59	26.79
6	0.07	12.78	4.57	31.36

Because of the lack of the required information, neither the ICP nor the depot maintenance activity is in a position to ensure that the actual elapsed maintenance shop time and the ICP file times approximate the standards established for the maintenance activity. And yet, the control of the actual time is a critical element in containing inventory investment costs, and at the same time, having serviceable assets available to provide responsive supply support.

Our analyses of the DoD policies and current Service practices for establishing time factors for the DRC segments leads us to the following conclusions:

- ◆ For a minimal inventory investment, realistic induction scheduling, and responsive supply support, the standard, actual, and ICP file RTATs must be approximately the same.
- ◆ The current DoD policy of using actual times is resulting in increased inventory investment and lack of timely repair of DLRs.
- ◆ The use of standards by the Army and the Navy for ICP file times would provide the opportunity for reducing RCLs.
- ◆ The exclusion of contract repair times (which are not engineered standards) from the determination of the average maintenance shop time for items with standards that are used as surrogate standards for other items would reduce Air Force RCLs.
- ◆ The reduction in RCLs provides the opportunity for inventory investment reductions and for one-time reductions in procurement and repair requirements.
- ◆ Standards should comprise the three types of engineered standards and standard allowances; their use would automatically prevent unanticipated delays from influencing the RCL.

THE RETROGRADE BASE SEGMENT AND CARCASS SHORTAGES

In many instances, retrograde processing is the longest DRC segment. Delays may contribute to the lack of unserviceable assets at the depot. One of the conditions that precludes timely scheduling and repair of unserviceable DLRs is the lack of unserviceable carcasses in the depot. The status of carcass availability based on the March 1995 Central Secondary Item Stratification (CSIS) report reflects a \$617 million shortage of the RCL (other war reserve- protectable and numeric stockage objective requirements are not included).

Normally, assets equal to the RCL should be on hand. To the extent that assets are in the supply system either at the retail level or in the retrograde pipeline, expediting their return would reduce the shortage that precludes scheduling and repair of assets to fill backorders and other urgent requirements.

At one retail activity we visited, unserviceable DLRs were physically moved four times (different buildings), from the time they were determined to be beyond the capability of maintenance until they were turned over to transportation. Returns were further delayed an average of 5 to 7 days while obtaining disposition instructions from the ICP (customer excess report/reply to customer excess report [FTE/FTR] transactions). For critical items, those delays contribute to the shortage of on-hand assets. No special procedures for expediting

processing are in place for those items that are in a critical or potentially critical asset position, e.g., items with on-hand assets below the RCL. The Air Force provides the identity of critical items to retail activities with the authority to return serviceable and unserviceable assets automatically using express transportation.

The Army and the Navy do not include retrograde requirements in their RCLs; therefore, requirements do not provide for making serviceable assets available for during the interval between receipt of a requisition at the wholesale level and the receipt of the unserviceable asset.

Our analyses of the current Service practices regarding the retrograde processing and its impact on the availability of serviceable assets leads us to the following conclusions:

- ◆ For items with wholesale on-hand carcass shortages, streamlining base processing by minimizing the number of physical movements and the time between determining that a critical unserviceable asset is beyond the capability of unit or intermediate maintenance and turning it over to transportation for expedited shipment to a depot could reduce the shortage.
- ◆ The inclusion by the Army and the Navy of the retrograde segment with the applicable assets in the RCL and improvements in the retrograde process could reduce the carcass shortage.

Process Improvement

DRCT STANDARDS

To provide serviceable assets during for the critical path time needed to repair unserviceable assets, the Services must invest in inventory. Because the amount of that investment is a direct function of DRCT, DoD should establish reasonable "should take" time standards as processing time goals for each segment of the DRCT for two key reasons.

First, a reduced RCL requirement, based on valid standard DRC, will reduce budget requirements and, over time, will require a smaller investment in inventory. Based on our line-item sample, the use of DRCT standards would significantly reduce RCL investment requirements.

Second, use of standards for each DRC segment permits optimal use of resources by providing managers with a tool to measure the performance of the depot repair process (by segment) and to take remedial management action required to improve performance.

We recommend that the Deputy Under Secretary of Defense (Logistics) take the following actions:

- ◆ Adopt the proposed DRCT standards shown in Table A-1 of Appendix A. Use of those standards as valid benchmarks in requirements computation, budgeting, and repair execution would focus both supply and maintenance management's attention on DRCT. Thus, the cost and ultimate support effectiveness of the depot repair process will be directly driven by the validity and use of and adherence to those standards.
- ◆ Adopt a mix of engineered time standards, work sample standards, and technical standards for this segment coupled with allowances for nonlabor, queuing, and movement times.

THE RETROGRADE PROCESS

Because of the adverse impact of carcass shortages, we recommend the following improvements in the base-processing and in-transit segments of the retrograde process:

- ◆ Require ICPs to identify the NSNs that are in a critical asset position, e.g., those with on-hand assets less than the sum of the requirements through the RCL.
- ◆ Require ICPs to provide information to retail activities' automated systems to (1) identify items authorized for automatic return without referral to the ICP, (2) indicate the need for expedited handling, (3) indicate the ship to destination, (4) authorize use of express transportation, and (5) permit the automatic generation of shipping documentation (similar to the Air Force's Reparable Item Movement Control System [RIMCS]).
- ◆ Require retail activities to improve base processing of returns by expediting the document flow and by minimizing the number of physical movements of an unserviceable asset from the point at which it is determined to be beyond the capability of maintenance until it is packed and turned over to transportation for shipment.

REPAIR CYCLE PERFORMANCE MEASUREMENT

Current Practices

Beyond differences in how it and its related segments are defined, DRCT is also measured differently across the Services as shown in Table 2-4.

The Army transactions record the beginning of RTAT with the change in Condition Code from F to M and the end with the change from Condition Code

M to A. The Army maintains document continuity between transfer in and out, thus facilitating the computation of the actual elapsed time. The times in the segments within the RTAT are only available from manual maintenance records. While the accounting system records the total RTAT by transaction (it includes AWP time), no measurement reports are generated. Maintenance shop standards are recorded in a different system. Standard, actual, and ICP file times are not routinely compared, and the ICP file time is determined by the IM.

Table 2-4.
DRCT Measurement by Segment

Segment	Army	Navy	Air Force
Retrograde			
Base processing	N/A	N/A	Measured with constraints
In-Transit	N/A	N/A	Measured with constraints
Repair turnaround	Recorded, not measured; includes all AWP time	Measured F to M start; M to A end; includes some AWP time	Recorded, not measured
Transfer-to-maintenance	Not recorded separately	Not recorded separately	Recorded, not measured
Maintenance shop	Not recorded separately	Not recorded separately	Recorded, not measured; includes some AWP time
Transfer-from-maintenance	Not recorded separately	Not recorded separately	Recorded, not measured

The Navy measures the total RTAT (including some AWP time) and computes an exponentially smoothed average for consideration in establishing the ICP file time. Times in segments within the RTAT are only available from maintenance records. The Naval Aviation Depots (NADEPs) use unit-specific bar coding to identify materiel throughout the maintenance process and its transfer back to storage, thus providing the means for measuring the actual time for each segment of RTAT. A standard RTAT is not available for comparison with the actual or ICP file time, and no routine comparisons of standard, actual, and ICP file times are made.

The Air Force uses standards as the basis for DRCT budgeting and execution. While the RTAT segments are recorded (they include some AWP time), neither the segments nor total actual RTAT is systematically measured. The ability to determine actual elapsed RTAT is further complicated by the use of different document numbers for induction and completion. Actual and standard RTATs are not routinely compared.

Evaluation

Our evaluation of the current Service policies and practices in measuring and evaluating repair cycle performance leads us to the following conclusions:

- ◆ The Services do not have systems for routinely measuring and comparing standard, actual, and ICP file DRCTs, which vary significantly, or for generating management reports to permit them to evaluate and improve the repair process.
- ◆ The Service do not evaluate the storage depot or depot maintenance performance on the basis of actual elapsed times compared to standard or required times.
- ◆ With the adoption of DRCT standards for wholesale requirements determination, induction scheduling, and DLR repair execution, supply and maintenance managers need to measure the actual elapsed DRCT being experienced and be able to take corrective action for significant delays or differences between actual and standard DRCTs.
- ◆ The NADEPs are able to measure the actual time for each segment of RTAT by using bar-coded-unique document numbers.
- ◆ Contrary to DoD policy, some or all of the AWP time (varies by Service) is included in the actual recorded time but not identified.
- ◆ Only the Air Force measures the actual base-processing and in-transit times and only its accounting system records each RTAT segment.

Process Improvements

Based on our evaluation of the current depot repair cycle performance measurement and management reporting, we recommend that the Deputy Under Secretary of Defense (Logistics) take the following actions:

- ◆ Establish standard procedures for recording the actual DRCT for each segment using unique document numbers to track units through depot maintenance and back to storage.
- ◆ Establish performance measurement and reporting requirements to collect and compare actual and standard DRCTs for each segment and in total. Where actual processing times differ materially from standard times, provide analyses and indicate the proposed management actions.
- ◆ Evaluate the performance of depot maintenance (organic and contractor) based on (1) comparison of actual and standard maintenance shop times and (2) comparison of actual and required delivery dates in addition to the current evaluation based on efficiency.

- ◆ Evaluate the performance of the ICP based on the delays in repair of DLRs due to (1) shortages of parts, (2) shortages of carcasses, and (3) validity of repair production forecasts.
- ◆ Establish a reasonable baseline (founded in segment standards) for use with emerging finite capacity scheduling and MRP II systems that will require detailed process flow metrics for all repair processes in the depot to function correctly.

UNANTICIPATED DELAYS DURING THE REPAIR PROCESS

Types of Unanticipated Delays

In concert with the move toward use of DRCT standards, management information systems and the requirements determination processes in place at Service ICPs must address the major unanticipated delays that are likely to occur during the repair process and that are neither a part of the DRCT nor included in the standards.

Three types of unanticipated delays need to be addressed because they are not accounted for as separate segments of the DRC nor included in the proposed standards (see Appendix A), but they increase the total time required to provide a serviceable asset. The delays include the following three major categories:

- ◆ *Awaiting parts.* AWP occurs when the depot does not have enough parts to repair the line item in question. Because of AWP, induction is delayed, induction quantities are constrained, and production is delayed.
- ◆ *Awaiting maintenance.* AWM occurs when the depot does not have the capacity to repair the line item in question. Because of AWM, induction is delayed, induction quantities are constrained, or production is delayed.
- ◆ *Awaiting carcasses.* AWC occurs when the depot does not have enough Condition Code F assets for the line item in question. Because of AWC, induction is delayed or induction quantities are constrained and production is delayed.

For example, data from one Service maintenance depot indicate that delays for carcasses and delays for maintenance capacity jointly accounted for more than 5 percent of underproduction (the actual repair volume was less than the planned repair volume) in FY94. While other service management information systems did not provide similar quantitative benchmark data, our interviews with depot maintenance managers clearly indicated that unanticipated delays for carcasses were common for selected items and often delayed a planned induction.

Similarly, delays caused by insufficient workcenter capacity were factors in excessive total repair process times for selected items. Accordingly, such unanticipated delays must be explicitly considered if DRCT standards are adopted.

None of these three categories of unanticipated delays is included in the DoD standard definition of segments of DRCT discussed earlier nor are these times a part of DRCT standards that we recommend. Indeed, the application of DRCT standards presumes that asset availability, parts availability, and maintenance capacity will not routinely affect the expected DRCT.

Evaluation

Our evaluation of the potential impacts of unanticipated delays on the total repair processing times and their relationship with the of DRCT standards leads us to the following conclusions:

- ◆ In order to evaluate actual performance compared to DRCT standards, the increased processing time resulting from each of the three types of unanticipated delays needs to be measured and accounted for separate from actual DRCT related to the standard DRC segments.
- ◆ When they occur, AWP, AWM, and AWC affect the length of the time required to produce a serviceable asset. Properly accounting for unanticipated delays separately enables us to account for performance evaluation and analyze major contributors to differences between DRCT standards and the actual DRCTs. It also permits us to analyze the frequency and magnitude of additional repair process time resulting from unanticipated delays. Failure to properly recognize and adjust for these unanticipated delays will undermine the use of DRCT standards and has the potential to degrade responsive support.

Process Improvements

There are two possible approaches to dealing with unanticipated delays in DRCT. One is to use historical data to include a "factor" for them in the DRCT standard for the item in question. That approach can distort the standard DRCT over time and may indeed lead to the invalidation of the standard. Additionally, inclusion of the delays increases inventory investment. A second, more discrete, approach is to treat such unanticipated delays statistically, using the established tools of probability theory, and keep any adjustments for such delays clearly separate and distinct from DRCT standards and actual DRCT.

We recommend that the Deputy Under Secretary of Defense (Logistics) make the following changes in accounting and providing for unanticipated delays:

- ◆ Separate accounting for unanticipated delays from DRCT segments to allow specific focus on those events (in frequency and duration by category) and to provide a clear audit trail.
- ◆ Enhance management information systems to measure the frequency and duration of each type of unanticipated delay to identify problem areas requiring management attention and collect information sufficient to compute the variance in these delays.
- ◆ Use repair processing variances caused by unanticipated delay factors when computing the wholesale repair safety-level requirement.

CHAPTER 3

Repair Programming, Production Planning, and Induction Processing

INTRODUCTION

To provide customers with responsive support in repairing depot-level reparables at minimal costs, management seeks to constantly maintain the correct balance of serviceable DLRs and unserviceable assets in process of repair relative to the appropriate current requirement levels. Achieving that objective requires the coordinated efforts of the ICP managing the DLR, the organic or contractor depot maintenance activities providing repair services, the wholesale integrated materiel managers (IMMs) for parts and local supply activities responsible for parts support, and the supporting depot storage activities.

The depot-level maintenance activities, the parts support IMMs, and the local supply activities require reliable information from the DLR managers (the ICPs) to plan and execute their respective roles in contributing to the generation of the *right quantity* of serviceable assets *at the right time*. In this chapter, we address three distinct but closely related processes needed to maintain the proper balance of serviceable assets on a timely basis: *repair programming*, *production planning*, and *induction processing*. Those processes range from long-term aggregate resource planning (*repair programming*), through mid-term capability planning and the coordination of time-phased repair plans for specific line items (*production planning*), to the near-term generation of workorders and actual physical repair and movement of a given component through the maintenance depot to meet today's asset requirement (*induction processing*).

Changes in supply and maintenance policies, system interfaces, maintenance capacity, workload, and priorities clearly affect current DRCTs, inventory investment requirements, and responsiveness to customers' needs. The three separate processes — repair programming, production planning, and induction processing — are each a joint responsibility of the maintenance and supply managers and must be carefully coordinated and linked over time to ensure an effective and efficient DLR repair program.

Repair Programming

The purpose of repair programming is to assure that capabilities and capacities of both organic and contractor repair sources and the related budgeting are integrated to match the projected DLR repair requirements. Repair programming should provide the capacity for "repair for stock," "concurrent overhaul

repair," inter-Service support, and foreign military sales (FMS). It should reflect changes in force structure, operating tempo, equipment modernization, and sourcing (organic or contractor depot) over the programming period.

The objectives of repair programming should be to

- ◆ ensure that the repair requirements projected by the cognizant ICPs and major item overhaul managers are adequately reflected in both supply and maintenance budget development;
- ◆ identify the source of the required capability, i.e., as organic and/or contractor;
- ◆ obtain the required resources; and
- ◆ acquire or adjust, as needed, the facilities, equipment, and a work force with the appropriate balance of skills to meet the outyear requirements.

Production Planning

Given effective long-term repair programming in providing the required maintenance resources, the next step is the joint planning for production by the wholesale inventory manager, the cognizant maintenance depot manager, and parts support activities. Production planning is typically conducted on annual, semiannual, and quarterly bases. The annual plan extends through the budget year. It includes the more detailed line-item coordination of maintenance capacity and supply repair needs. That coordinated planning for the production of the forecasted repair workload (for stock, concurrent repair, and inter-Service) is a key mid-term planning activity that links repair programming and actual repair induction processing.

The objectives of production planning should be to

- ◆ provide the depot maintenance activity, on the basis of the most current data, with current forecasts by NSN of variable monthly repair requirements;
- ◆ ensure that the depot maintenance capability is adequate to meet the annual repair projections;
- ◆ provide the capability to meet fluctuating requirements to an agreed-upon level above the ICP projections and to accept induction workorders up to that level without further negotiation;
- ◆ tentatively reserve or allocate depot capacity for repairing specific components in given quantities over the planning period (quarterly, semiannually and annually);

- ◆ determine how peak requirements will be satisfied (e.g., overtime, extra shifts, subcontracting, temporary employees, or cross-training);
- ◆ provide more-current estimates for the subsequent 2nd, 3rd, and 4th quarters and reflect the monthly variance from the annual average for all quarters;
- ◆ provide annual repair parts requirement forecasts to the supporting ICP a budget and procurement lead-time away and quarterly forecasts to the supporting installation supply support activity a requisition lead-time away; and
- ◆ identify potential unserviceable carcass shortages and AWP conditions.

Induction Processing

Induction processing is the final, near-term, execution step in the overall DLR repair process. It entails determining how many units of an item are to be repaired on a given workorder and when those items should be inducted into the repair process, obtaining the necessary piece parts, physically moving the piece parts and unserviceable DLRs from storage to the depot repair facility, completing their repair, returning them to storage, and recording the serviceable asset on the ICP records. As is the case with the other two elements of the DLR repair process, induction processing involves coordinated actions by both supply and maintenance managers.

The objectives of induction processing should be to

- ◆ produce the number of serviceable DLRs required to maintain the proper balance between the current asset position and the appropriate requirement levels,
- ◆ provide the flexibility needed to schedule and repair unserviceable assets to meet fluctuating near-term serviceable asset shortages,
- ◆ preclude the encumbrance of maintenance capacity by the induction of materiel not needed immediately based on current asset position,
- ◆ minimize the elapsed maintenance shop time by controlling early induction and overinduction, and
- ◆ place funded repair orders with minimal lead-time.

In the following sections, we analyze each of these critical DLR repair processes and propose changes to current policies, procedures, and systems.

CURRENT POLICIES AND PRACTICES

Repair Programming

Although each Service has its own unique processes and data systems for repair programming, their initial computation of requirements and their budget formulation processes show some similarities. Requirement determination is the foundation for budget requirements and provides the basis for projections of annual repair volumes. Most systems use assumptions based on current demand or failure and return rates. Thus, the availability of current program data for the entire forecast period (as long as five to seven years) is critical to acceptable long-term forecasts. The availability of the most recent projections of program data is particularly important during periods of expansion, downsizing, changes in operating hours, and modernization.

Because repair programming is generally done over a multiyear planning horizon and may use steady-state failure and demand projections, actual production planning of requirements for a given line item and, subsequently, the induction processing and repair of that item frequently differ both in timing and in the quantities involved.

Current repair programming activities are viewed as *aggregate resource planning and budgeting efforts* and are properly oriented to aggregate measures. Repair programming is an essential prerequisite process in providing adequate resources, facilities, equipment, and work force to enable organic and contractor depot-level repair to be responsive to the ever-changing customer support requirements for stock and concurrent repair.

In each Service, the lack of depot maintenance capability to repair the total workload necessary to maintain the required balance of on-hand serviceable assets constrained production planning and induction processing.

Production Planning

Production planning links line-item repair requirements to depot maintenance repair planning. Policies, procedures, and systems used by the Military Services to plan repair activities vary widely. Nevertheless, all Services generally utilize the wholesale inventory management line-item records to project repair needs over time on the basis of forecasts of item failures, returns, and asset position. Those data allow the IM to identify item-specific repair forecasts as the input to production planning.

Production planning in most Service systems is based on forecasted requirements, and data underlying those forecasts and associated asset position may be up to a year old at the time the repairs actually occur. Service production planning may cover one quarter, two quarters, and/or an annual repair plan leveled over four quarters. The level quarterly requirements are submitted to the

appropriate maintenance activities for coordination. Such level projections fail to inform maintenance of the true asset status and varied workload. That workload ranges from items with due out requirements and safety-level deficiencies that call for extremely high initial production to "catch-up" and then declining to production for serviceable assets in long supply that may not require induction until the 3rd or 4th quarter. The cognizant repair depot assesses existing and planned depot capacity and workload (including principal item overhaul or modification) to determine its ability to meet projected repair needs for the line item. Usually joint supply/maintenance reviews result in a negotiated production plan. During the negotiations, the quantities may be adjusted, usually downward, because of possible carcass or parts shortages and lack of maintenance capacity.

Through that process of production planning, repair "schedules" are negotiated on a mid-term cyclical basis, and they, in turn, become the basis for funding repair activities and, ultimately, for the actual induction and repair of assets. Although actual repair requirements change daily, the negotiated schedule is accepted or confirmed for the next quarter, two quarters, or year. The production plan usually becomes a commitment to induct the forecasted quantities with a minimum of one quarter's requirement funded. Induction is at the discretion of the maintenance activity within the funded requirements.

Induction Processing

Induction processing today is not clearly distinguishable from production planning. In general, maintenance activities are authorized to induct unserviceable assets up to the funded limit of the negotiated production plan, and funding is usually provided in quarterly or greater increments. Within the negotiated production plan and funding limitations, maintenance typically makes the induction decisions. Once assets are physically inducted for repair, they are unlikely to be "deinducted" based on changes in requirements or assets; therefore, increasing production for "new requirements" other than those needed to meet high-priority requisitions is difficult.

Current practices frequently result in the induction of quantities in excess of the immediate need on the basis of current asset positions, and those quantities often exceed near-term maintenance production throughput capacity. One Service encourages immediate induction of the quarterly funded quantity.

Another holds biweekly reviews of the production plan. However, those are primarily devoted to reestablishing priorities for previously forecasted requirements for the ensuing two weeks rather than revising schedules based on current serviceable asset shortages.

Yet another Service determines a portion of its induction requirements on a weekly basis. That more-current determination of induction requirements applies to only about 20 percent of its maintenance requirements (low-frequency and low-dollar-value items).

EVALUATION

Introduction

Because the three processes — repair programming, production planning, and induction processing — are so intertwined under current policies and practices, our evaluation covers the three processes combined. During our field research, we collected from the ICPs sample data on items repaired at the maintenance activities we visited. The sample data indicated potential imbalances between the items and quantities in the repair process and those currently required to provide responsive supply support. The sample data also provided insight into the size of the induction quantity relative to the demand rate for the item and the maintenance production rate.

We next examined CSIS report data to determine whether the sample was representative of the total repairable spectrum. By using the item sample and summary stratification data, we were able to examine the end results of the three processes.

In our study, we found that our evaluation of DRCT was critically dependent on the answers to the following two specific questions on current DoD induction processing policies, procedures, and systems:

- ◆ *How far in advance of “expected repair activity” are assets inducted into maintenance?* Since in most systems, induction processing starts the measured RTAT, so-called “early inductions” (assets physically inducted well in advance of the hands-on repair action on all or part of the lot) result in an overstatement of the DRCT and associated inventory investment, i.e., the RCL.
- ◆ *How many assets are inducted in a given repair lot?* Closely related to the timing issue, the repair lot size issue affects the flexibility of the induction processing system to react to changes in requirements. The larger the lot size, the greater the impact. Also, since some or all of a large repair lot will not be physically repaired immediately, such induction tends to overstate the DRCT and associated RCL inventory investment.

Sample Items

LATE/UNDERINDUCTIONS

The following two examples illustrate failure of the DRC process to produce adequate numbers of serviceable assets early enough to satisfy current on-hand serviceable asset requirements through the safety-level requirements. Based on the RTAT, the condition will continue because of the failure to induct unserviceable assets into the repair process soon enough.

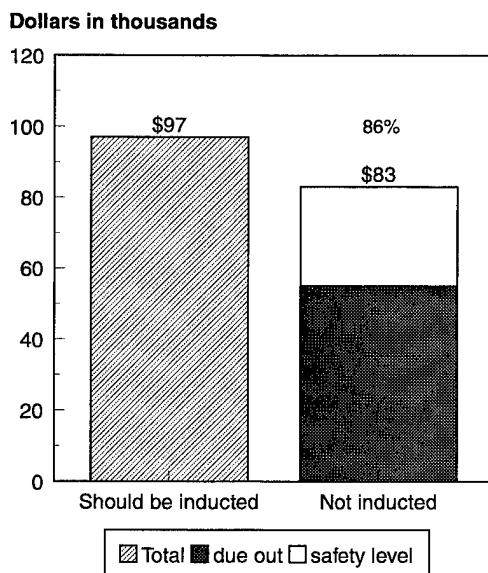


Figure 3-1.
Underinduction

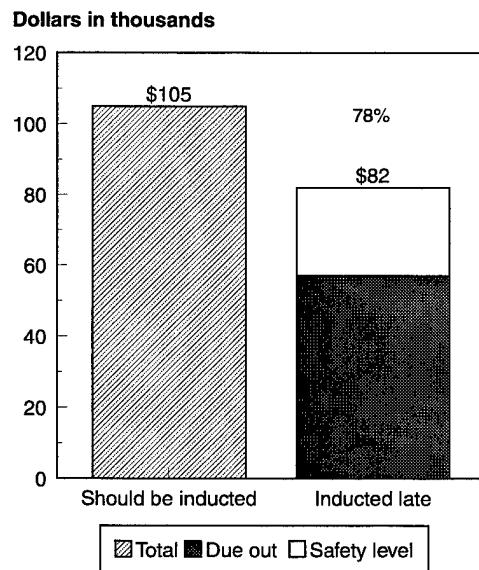


Figure 3-2.
Late Induction

Figure 3-1 displays the data for a loop assembly for which 86 percent of the unserviceable assets on hand that should have been inducted were not inducted. Two-thirds of those *not inducted* were required to satisfy existing backorders (due out quantities). The remaining one-third was needed to meet safety-level deficiencies. The 14 percent that was inducted was too late to satisfy existing backorders.

Figure 3-2 displays the data for a dome and housing assembly. In contrast with the example in Figure 3-1, this example shows that more than enough unserviceable assets had been inducted (\$174,000) to meet the requirements through the repair cycle level of \$105,000. However, 78 percent or \$82,000 of the \$105,000 worth of assets that *should be in maintenance* was not repaired in time to preclude \$57,000 due out (backorders) and \$25,000 safety-level serviceable asset shortage.

Figures 3-1 and 3-2 illustrate undesirable outcomes from the current repair programming, production planning, and induction processes for the following reasons:

- ◆ On-hand unserviceable assets were not inducted in quantities adequate to satisfy current deficits up through the repair level, including items with backorders and with safety-level deficits.
- ◆ Some assets that were inducted into maintenance were not inducted in time to maintain the proper balance of serviceable assets and current requirements.
- ◆ The frequency that this condition occurred within the sample items along with an analysis of the current business processes suggests that the problem is systemic.
- ◆ Some of what appears to be too little or too late induction/production may be attributable to AWP, changes in failure rates, or AWM.

EARLY INDUCTIONS/OVER INDUCTIONS

Most activities we visited induct assets in quantities larger than their immediate processing capacity and in excess of near-term requirements. Induction of an entire quarterly requirement at one time is not uncommon — and some items were inducted in even larger quantities.

The following two examples from the sample items depict early induction and/or overinduction based on the relationship between the quantity in maintenance (Condition Code M) and the portion that is above the current requirement objective (RO). Normally the quantity in Condition Code M would not be expected to exceed the repair cycle level.

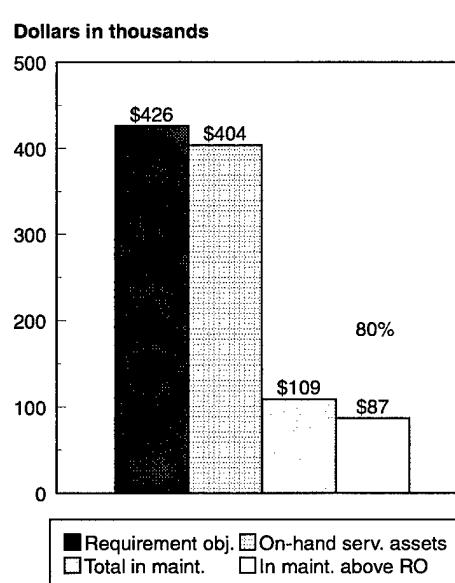


Figure 3-3.
Early Induction

Figure 3-3 displays the data for a power supply. The on-hand serviceable assets (\$404,000) were equal to 95 percent of the requirements objective, and additional assets worth \$109,000 were in maintenance. Thus, assets worth \$87,000, or 80 percent of the inducted assets were above the RO. At the total demand rate (recurring and nonrecurring), the in maintenance assets would not be brought down to the RO for five months with no more inductions.

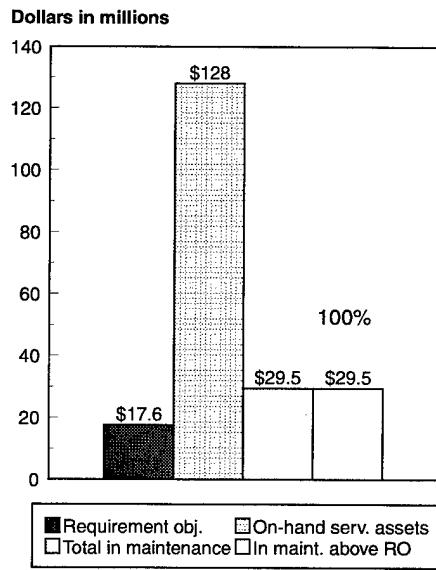


Figure 3-4.
Overinduction

Figure 3-4 shows the data for an engine. The on-hand serviceable on-hand assets were 7.3 times greater than the requirement objective. Of the \$29.5 million in assets in maintenance, all was above the RO. At the total demand rate, the on-hand serviceable assets would not be brought down to the RO for 3.2 years. An additional 10 months would be required to consume those in maintenance if no additional engines were inducted.

In each of the examples, the magnitude of the on-hand serviceable asset in relationship with the RO appears too large to dismiss the early induction/over induction as the result of a sudden change in the requirement or asset positions. The commitment of repair capacity to those early induction/over inductions may preclude the induction of items in the late induction/under induction status as reflected in Figures 3-1 and 3-2.

RELATIVE SIZE OF INDUCTIONS

In the sample items shown in Tables 3-1 and 3-2, we examine the quantity inducted relative to the demand for the item.

Table 3-1.
Turbine Nozzle

Date	Quantity inducted	Months of demand
94-032	69	4.4
94-076	12	0.8
94-095	5	0.3
94-146	11	0.7
Tot/avg	97	1.6

Table 3-1 displays the data for a turbine nozzle. The average monthly demand (recurring and nonrecurring) was 15.7 units. The first induction of 69 (total value = \$1,096,410) represents the equivalent of 4.4 months of average total demand. That induction did not represent an effort to "catch-up" because the on-hand serviceable assets and the assets in maintenance *each* exceed the requirements through the repair cycle. The elapsed time from the first to the last induction was 3.7 months. The total quantity inducted was 97 units or enough to satisfy 6.2 months of total demand. Inductions averaged 1.6 months of demand.

Table 3-2.
Recorder

Date	Quantity inducted	Months of demand
93-137	7	2.5
93-201	7	2.5
93-223	12	4.3
93-291	4	1.4
93-323	6	2.1
93-349	2	0.7
Total/avg.	38	2.3

Table 3-2 displays the data for a recorder (unit cost = \$4,723). The average total monthly demand was 2.8 units. The on-hand serviceable assets exceed the requirement objective. The inductions ranged from 0.7 to 4.3 months of average total demand. The elapsed time from the first to last induction was 7 months, and the total quantity inducted was 38 units, or enough to satisfy 13.6 months of demand. The value of the overinductions for the 7 months was \$87,281.

Tables 3-3 and 3-4 display data for two additional examples of large inductions/early inductions. The following analyses are from the perspective of a production rate rather than that of a demand rate.

Table 3-3.
Radar Dome Assembly

Price \$33,349	Std 16	ICP file 16	Act 38
Date	Qty (in)	Qty (out)	Days
94-003	8		
94-004	12		
		1	18
		2	23
		2	28
		2	30
		1	33
		1	36
		2	37
		1	38
		1	43
		1	44
		1	45
		2	50
		2	51
		2	56
Total/avg.	20	20	38

Table 3-4.
Servo Cylinder

Price \$3,290	Std 4 days	ICP file 94 days	Act 137
Date	Qty (in)	Qty (out)	Days
94-006	67	11	25
94-040	25	2	34
		2	38
		10	78
		8	91
		3	93
94-102	8	2	105
		2	114
		1	164
		10	211
		8	224
		15	231
Total/avg.	100	74 ^a	137

^aRepair was not completed on 26 units

Table 3-3 depicts the inductions of 20 units of a radar dome assembly that occurred on two consecutive days. The production took place over a total elapsed time of 57 days of which 16 days (based on the standard) was the RTAT for one unit. The average RTAT was 38 days. The average steady-state production rate was approximately 1 unit per 2 days $[(57 - 16)/20 = 2.05]$. The first induction of 8 units represents approximately 30 days of production (assuming that the first unit took 16 days), and the second induction of 12 units, 1 day later, represented approximately 24 additional days of steady-state production. The two batches represent the production capacity for the next 56 days.

Table 3-4 shows the three servo cylinder inductions of 100 units that occurred over a 96-day period. The production took place over a total elapsed time of 232 days of which 4 days (based on the standard) was the RTAT for one unit. The average RTAT was 137 days for the 74 units completed as of the cutoff date. (Completion of the remaining 26 units will increase the average RTAT.) The average steady-state production rate was approximately 1 unit per 3 days $[(232 - 4)/74 = 3.08]$. The first induction of 67 units represents approximately 200 days (more than 6.5 months) of production (assuming that the first unit took 4 days. Combined, the second and third inductions of 33 units represented approximately 99 additional days of steady-state production.

Tables 3-5 and 3-6 summarize the effects of early inductions/ overinductions.

Table 3-5 shows that the weighted average number of radar dome assembly units in the repair process was 9.1 units with a value of \$303,476. If the units had been inducted at the steady-state production rate of 1 unit per 2 days, the weighted average in-process materiel would have been 5.7 units with a value of \$190,089 or \$113,387 (37 percent) less in-process inventory to produce the same quantity in the same time frame. The average actual RTAT of 38 days was 2.4 times the standard of 16 days.

Table 3-5.
Radar Dome Assembly Early Induction/Overinduction Summary

	Avg. units in process	Avg. value in process	Max. units in process	Max. value in process	RTAT days	Required RCL ^a
Optimum	5.7	\$190,089	8	\$266,792	16	\$266,792
Actual	9.1	\$303,476	20	\$666,980	38	\$633,631
Difference	3.4	\$113,387	12	\$400,188	22	\$366,839

^aInvestment level required to support demands during the RTAT. Assumes demand equal to production rate.

Table 3-6 shows that the weighted average number of servo cylinder units in the repair process was 32 with a value of \$105,280. If the units had been inducted at the steady-state production rate of 1 unit per 3 days, the weighted average in-process materiel would have been 1.2 units with a value of \$3,948 or

\$101,332 (96 percent) less in-process inventory to produce the same quantity in the same time frame. The average actual RTAT of 137 days was 34 times the standard of 4 days.

Table 3-6.
Servo Cylinder Early Induction/Overinduction Summary

	Avg. units in process	Avg. value in process	Max. units in process	Max value in process	RTAT days	Required RCL ^a
Optimum	1.2	\$3,948	2	\$6,580	4	\$4,382
Actual	32	\$105,280	79	\$259,910	137	\$150,093
Difference	30.8	\$101,332	77	\$253,330	133	\$145,711

^aInvestment level required to support demands during the RTAT. Assumes demand equal to production rate.

We examined the impacts of early inductions/overinductions from three different perspectives: a comparison of assets and requirements (Figures 3-3 and 3-4), the rate of induction and demand when no “catch-up” was required (Tables 3-1 and 3-2), and the rate of induction and production (Tables 3-3 through 3-6). Those analyses disclose the following adverse effects from early induction/overinduction:

- ◆ They increase the actual RTAT and, when used in the computation of the RCL, increase the investment in inventory. If the actual RTAT is not used in the computation, the amount of inventory required to sustain issues during the actual RTAT is understated, leading to a potential adverse effect on responsive supply support.
- ◆ They increase the in-process inventory and space occupied by materiel awaiting hands-on processing without increasing production (less in-process inventory would produce the same quantities in the same time frame).
- ◆ They result in the induction of quantities not supported by asset position, demand rate, or production rate.
- ◆ They reduce scheduling flexibility by overcommitting to less-urgent requirements maintenance capacity that may be needed for higher priority requirements (late inductions/underinductions).
- ◆ They mislead the IM as to when serviceable assets will be available.
- ◆ They cause maintenance funds to be committed early and that commitment may require adjustments, particularly at the close of the fiscal year.

Summary Stratification Data

Because of the relatively small number of sample items provided with complete ICP and depot maintenance data, we examined a broader database to determine whether the sample items were representative. The one common source of appropriate and readily available data is the CSIS or STRAT reports prepared by the Army, Navy, and Air Force. The stratification tables (Budget Opening Position, Table I, of CSIS) reflect data as of 31 March 1995 and are the basis for the BES.

The opening position data is the logical source for determining whether the sample items were representative because it reflects the status of requirements and assets as of the cutoff date without the influence of any simulation. It also properly sequences all of the requirement levels and assets for the comparison. The requirements reflect the new forecasts for the ensuing quarter; therefore, some of the imbalance between requirements and assets is due to the requirement churn and does not yet reflect subsequent management actions based on those changes. Because of several other factors, including the variances in demands, returns of serviceable assets, washout rates, and receipts from procurement, we expect some differences between requirements and assets as the normal cost of doing business.

Figure 3-5 (early inductions/overinductions) and Figure 3-7 (late inductions/underinductions) display the stratification data over a five-year period rather than a single snapshot. Figure 3-6 displays the early induction/overinduction data at the end of the current fiscal year based on the opening position and six months of simulated actions.

The imbalances reflected in these figures should not be misconstrued as a budget issue. To the contrary, in 1995 the underinductions of \$2.9 billion exceeded the overinductions of \$1.8 billion by \$1.1 billion. *Budget evaluations should not be based on these data. However, the data do indicate the need for improved business practices for production planning and induction processing.*

EARLY INDUCTION/OVERINDUCTION

Figure 3-5 compares the dollar value of total assets in maintenance with the dollar value of assets in maintenance not supported by current requirements, i.e., the RO. The data show a very consistent pattern of the degree of the early induction/overinduction. Over the five-year period, roughly one-third of the assets in maintenance have exceeded the current requirement. The magnitude of the early induction/overinduction is too great to be attributed solely to requirement churn.

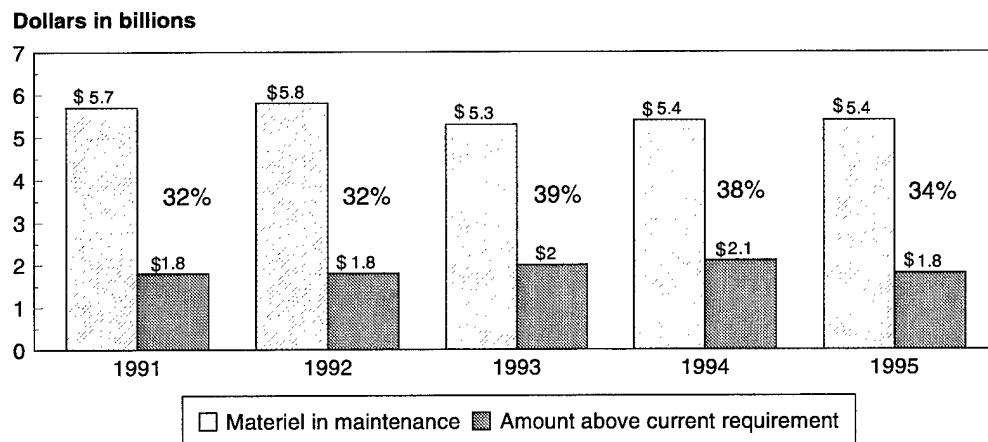


Figure 3-5.
Assets in Repair Above Current Requirements — Opening Position

Figure 3-6 reflects the same 1995 data modified by simulating receipts, issues, and other actions for six months from the opening position to the end of the fiscal year. The simulation process reflects a perfect world with events occurring as forecasted (no additional inductions of the items with adequate assets). Even in this controlled environment, \$1 billion, or more than 50 percent, of the overinductions remain above current-year requirements after six months of issues.

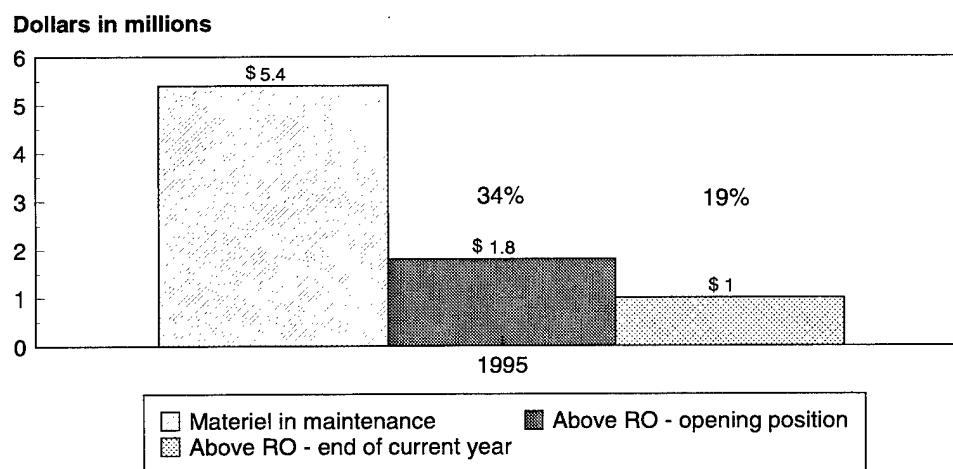


Figure 3-6.
Assets in Repair Above Current Requirements — End of Current Year

LATE INDUCTION/UNDERINDUCTION

Figure 3-7 provides similar information for cases in which a basic requirement exists for repair and unserviceable assets are available to meet the repair requirement but those assets have not been inducted into maintenance. In evaluating the data in Figure 3-7, we have adjusted the requirements from the "prepositioned war reserves, protectable," up through the "repair cycle level" to exclude "other war reserves" and "numeric stockage objective" requirements; thus, we included only the "basic demand-based requirements" that drive repair. Even given that adjustment, the portion of *not in maintenance* is over 50 percent of the total basic requirement for which assets are available. That condition suggests that the current business practices for production planning and induction processing need to be improved to support valid repair requirements effectively.

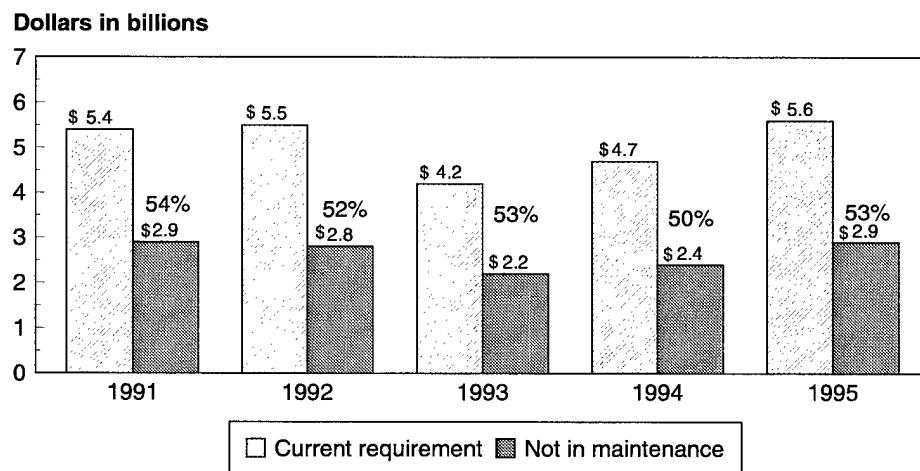


Figure 3-7.
Basic Requirement Deficiencies — On Hand, Not in Maintenance

CAPABILITY

Both depot maintenance and ICP personnel indicated that during the annual production planning negotiations, requirements are reduced because of perceived capability constraints. Additional reductions from the planned production are made during the course of the execution year for "lack of capacity." The data displayed in Figures 3-5 and 3-6 suggest that the problem — at least in part — may be one of preempting the available capability to repair assets not currently required rather than an absolute capacity shortage.

Conclusions

The above findings document major imbalances between the materiel *that is in maintenance* and the materiel *that should be in maintenance* based on current

requirement and asset data. We believe that the current business practices, especially production planning and induction processing, are major contributors to those imbalances. Early induction/overinduction cause the actual RTAT to exceed the standard time. If the actual RTAT is used in the RCL, the inventory investment is increased to sustain issues during the longer period while the unserviceable asset is being repaired; if it is not reflected in the RCL, the inventory is inadequate to sustain those issues. Early induction/overinduction also reduces the flexibility to meet changing priorities.

Our evaluation leads to the following conclusions:

REPAIR PROGRAMMING

- ◆ Valid repair programming requires the use of current data covering such factors as changes in force structure caused by expansion or downsizing, mission changes, changing operating hours, equipment modernization, and production enhancements over the entire forecast period.
- ◆ Repair programming must recognize the variability of repair requirements and provide capability flexibility.

PRODUCTION PLANNING

- ◆ Production plans should be just that, *plans* to determine *how* depot maintenance activities can ensure having adequate capability (overtime, extra shifts, temporary employees, cross-training, or subcontracting) to complete the entire workload on time (repair for stock, concurrent repair for overhaul, inter-Service, and FMS).
- ◆ Production planning based on annual averages will not provide the capability required for the timely completion of a workload that ranges from items with backorders (due outs) and safety-level deficiencies requiring very high initial "catch-up" production and then declines to items in long supply of serviceable assets that may not require small inductions until the 3rd or 4th quarter.
- ◆ Production plans should provide the capability to meet fluctuating and agreed-upon variance above the ICP-forecasted item repair requirements and provide for processing induction workorders within those ranges without further negotiations.
- ◆ Production planning should provide at least an annual plan through the budget year with variable monthly increments, provide quarterly updates prior to each quarter based on the latest requirement and asset data, and include repair part usage forecasts.

INDUCTION PROCESSING

- ◆ The frequency that imbalances between *materiel in maintenance* and *materiel that should be in maintenance* occurred in the sample items and the magnitude of those imbalances reflected in the summary data are too great to result solely from requirement churn. They indicate systemic problems and a need for business practice improvements.
- ◆ Many of the scheduling deficiencies observed (early induction/over-induction and late induction/underinduction) were directly or indirectly a result of practices that essentially used mid-term production planning projections based on relatively old requirement and asset data as the basis for funding and authorizing maintenance to induct one or more quarters of requirements.
- ◆ Large and/or frequent inductions exceeding requirements and production capacity are major contributors to the excessive actual elapsed maintenance shop time and in-process inventory.
- ◆ Induction processing should be uncoupled from production planning.
- ◆ The *actual elapsed* RTAT, the ICP *file time* used to compute the RCL, and the *RTAT standard* must have a high degree of consistency to minimize inventory investment, provide optimum assets to sustain issues during the repair process, and provide a reliable basis for generating repair workorders and required dates.
- ◆ Funded workorders should be generated on a more frequent cyclic basis, should cover requirements to the next cycle, and should be based on the asset position at the time the order is generated.
- ◆ Induction lot size (the quantity of assets to be physically moved into the repair process) should be based on the administrative and physical cost of picking and moving the lot to maintenance, maintenance setup cost, investment cost to acquire and hold additional inventory, and production throughput capacity.
- ◆ The induction process should provide for the administrative lead-time (from the asset cutoff point to the beginning of RTAT) required for the ICP to generate and transmit the workorder to maintenance and for maintenance to schedule production and to order and receive the materiel.
- ◆ ICPs need automated scheduling systems utilizing current requirement and asset data to generate frequent cyclic repair workorders.
- ◆ Depot maintenance activities need automated systems such as finite capacity scheduling and MRP II to minimize in-process inventory and to provide flexibility in meeting the fluctuating and changing requirements reflected in more frequent workorders for smaller quantities.

- ◆ Maintenance performance evaluation should focus on the variance between actual elapsed maintenance shop times and standards and on the percentage of on-time production.

PROCESS IMPROVEMENTS

Introduction

With \$1.8 billion, or 34 percent, of the assets in maintenance above current requirements and with another \$2.9 billion, or 53 percent, of on-hand unserviceable assets with current basic requirements but not yet inducted, the present business practices for repair programming, production planning, and induction processing are not producing an acceptable balance of serviceable DLRs. Those practices also result in excessive actual elapsed RTATs compared to standards, and that, in turn, increases the inventory investment required to sustain issues during the RTAT. Those business practices are in urgent need of process improvements.

Thus, our assessment of the results from the existing business practices suggests that nothing less than a major reorientation and coordinated process changes by both supply and maintenance activities will bring about the needed improvement.

We recommend that the Deputy Under Secretary of Defense (Logistics) make the following process improvements.

Repair Programming

We did not review the repair programming process in depth. However, on the basis of our field research, we suggest several process improvements. The overall objective (other objectives are stated in the introduction to this chapter) is to acquire or adjust, as needed, the resources, facilities, equipment, and a work force with the appropriate balance of skills to meet the outyear maintenance requirements.

Repair programming process improvements

- ◆ Provide those personnel developing the workload forecast with the latest available data on changes in force structure, operating tempo, and equipment modernization and phase out over the *entire* programming horizon not merely the near term.
- ◆ Coordinate the programming of DLR repair for stock, concurrent repair of DLRs generated from end-item overhaul, and inter-Service requirements to ensure adequate capability for all.

- ◆ Justify the minimum acceptable level of production outside the normal system in those instances that retention of a "warm repair base" that exceeds current requirements is identified.

Production Planning

The major change recommended for production planning process change is the uncoupling of workorders, funding, and induction authorization from the production planning process.

Production planning process improvements

- ◆ Reorient production planning with the objective of determining *how* the forecasted workload can be completed (overtime, extra shifts, temporary employees, cross training, or subcontracting). That planning represents a challenge and fundamental change from the current practice of adjusting repair requirements to match maintenance capacity.
- ◆ Develop, as a minimum, an annual plan with variable monthly requirements and three quarterly updates for the 2nd, 3rd, and 4th quarters using the most current asset data for all items. The plans should provide variable monthly estimates and be coordinated and distributed 45 days before the beginning of the period.
- ◆ Identify potential unserviceable carcass shortages and AWP problems.
- ◆ Predicate production planning on the premise of providing flexibility to meet fluctuating item repair requirements with a goal of on-time (elapsed time based on standards) processing of repair workorders varying by an agreed-upon percentage above the forecasted item workload without further negotiation.
- ◆ Require ICPs and depot maintenance activities to jointly forecast and disseminate the piece part requirements in conjunction with the production plan. They should also provide the annual forecast to the piece part IMM and each quarter's forecast to the installation supply activity (or contractor's activity) supporting the depot maintenance activity (see Chapter 4 for a more detailed discussion of the AWP problem).
- ◆ Establish the objective of not more than one to two weeks of authorized but not yet in-process workload, including fiscal year carryover.

Induction Processing

The key to reducing the substantial imbalance of overinduction and under-induction, reducing the actual RTAT, and improving the flexibility of today's repair of DLRs is to establish induction processing as clearly separate from, but

related to, production planning. Coordinated quarterly production planning volumes with monthly increments or targets with an agreed-upon maximum variance above the forecast would represent the planned commitment by the maintenance depot. The specific timing of short-interval repair and funding authorizations during the quarter and the quantities of assets to be repaired should be the purview of the wholesale inventory manager. The funded repair workorder should be initiated by the IM within the constraints of the planned production target without requiring further coordination. Conversely, if maintenance cannot complete the total workload by the required date, maintenance will inform the ICP of the facts and propose alternative courses of action. Finally, each specific repair induction should be based on a prioritized workorder that would allow the maintenance depot to focus repair capabilities on the most critical items.

Induction processing improvements

- ◆ Revise the business practices related to induction processing generally along the lines of the detailed proposal for improving induction processing presented in Appendix A. It includes the following proposed key process improvements:
 - ▶ Decoupling induction processing from production planning
 - ▶ Executing repair authorization and funding on a biweekly cyclic basis with workorders generated an administrative lead-time plus the standard RTAT for the item in advance of the required date for the serviceable assets using requirement and asset data as of the cutoff
 - ▶ Providing depot maintenance activities with automated systems such as finite capacity scheduling and MRP II to give them the capability and flexibility required to react to smaller and more frequently funded repair orders reflecting variable requirements, priorities, and shorter required dates.

By constraining repair workorders to 14 days usage and assuming a weighted RTAT of 49 days, an average of 3½ lots would be in repair (steady-state projection) at a point in time (using DRCT standards proposed earlier) for a given item. We believe that level is workable in today's system. Over time, with improvement in processing efficiencies, a further reduction in repair workorder size should be an objective.

We believe that, collectively, the changes recommended in induction processing, including funding, will substantially reduce actual DRCT, will cut RCL inventory/investment requirements, will minimize the imbalance of overinduction and underinduction, and will materially increase the flexibility and responsiveness of today's DLR repair process.

CHAPTER 4

Materiel Support and Awaiting Parts Delays

INTRODUCTION

The repair of depot level reparables is critically dependent on the availability of repair parts. These bit and piece parts (and often subassemblies) are consumable or repairable items that are used in the component repair process. Just as the repair of unserviceable carcasses is projected, the requirements for repair parts must be forecasted, the parts positioned, and those assets protected for subsequent use in the repair process.

Because DLR repair is the major source of assets to meet end-customer operational support and achieve weapon system readiness, the component repair process must produce serviceable units on time and avoid unanticipated delays, including any time delay caused by the absence of parts needed in a repair task. Further, the level of materiel support provided to the depot repair shops is a major factor that extends the repair process when it is impaired by delays. DRCT standards presume that enough parts are available and postulate that materiel support will not normally affect the expected DRCT.

In this chapter, we present a review of the materiel support for the depot component repair process. We focus primarily on AWP time — the time period during which repair is delayed awaiting the receipt of parts — and how that type of unanticipated delay interrupts a smooth repair flow. We evaluate the DoD policy of excluding AWP time from DRCT and analyze the implementation of that policy by the Services. We also analyze materiel support policies, procedures, and the associated information systems, and make recommendations for improving materiel support and controlling AWP time.

CURRENT POLICIES AND PROCEDURES

Policies

AWAITING PARTS TIME EXCLUSION

Until DoD Regulation 4140-1.R was revised in 1993, DoD policy did not specifically address the issue of excluding AWP time in the DRCT. It did, however, specify the elements of the repair process that were authorized for inclusion in the DRCT, and they did not include AWP time. The new regulation continued

that policy and further extended it by specifically excluding AWP time from DRCT.

The Army uses the actual RTAT or an IM-determined factor. Both include AWP time. Once a DLR is inducted into maintenance, the Army does not have a policy to place that item in Condition Code G if a long delay is expected; thus, any AWP time subsequent to induction is reflected in the actual maintenance shop time and affects RCL. The AWP time for DLRs that are awaiting parts but have not been inducted is not reflected. The Army also inducts assets in order to "rob-back" (cannibalize) parts to temporarily overcome the parts shortage that would otherwise result in a work stoppage. Because DLRs inducted under those conditions are not recorded in Condition Code G, that time also adds to the maintenance shop time. That practice also ties up repair funds.

The Navy uses an exponentially smoothed actual RTAT or an IM-determined factor. Both include some amount of AWP time. The Navy's policy provides for the use of Condition Code G when delays of more than 45 days are anticipated. When Condition Code G is used, the AWP time is excluded from the RTAT.

The Air Force uses standards for the RTAT portion of its RCL, and awaiting parts time is not included in those standards. The Air Force also uses Condition Code G in those instances that the AWP time is expected to exceed 30 days. Air Force actual RTAT's, therefore, include some AWP time.

PARTS SUPPORT RESPONSIBILITIES

DoD policies do not set forth the specific roles of the activities and processes that must provide responsive supply support to the depot maintenance activities. Current policies are primarily those of each DoD Component even though with Phase II of the Consumable Item Transfer, DLA is becoming the predominant supplier of piece parts and the processes involve activities under separate commands and geographic locations. The activities involved include

- ◆ the depot maintenance activities themselves (accumulating and providing to the ICP managing the DLRs valid piece part consumption data per DLR) for providing near-term requirements a requisitioning lead-time away to their local supply support activity and for maintaining appropriate shop or bench stock levels;
- ◆ the ICP responsible for managing the DLRs (forecasting the number of DLRs to be repaired and the total parts consumption by time period, properly coding the essentiality of the piece parts, and providing that information on both to the IMMs);
- ◆ the IMMs for the piece parts (developing the appropriate acquisition and distribution strategies to ensure satisfactory availability and minimal AWP time); and

- ◆ the local supply activities (Installation Supply Activity [ISA], Fleet and Industrial Supply Center [FISC], or Depot Maintenance Support Center [DMSC]) supporting the depot maintenance activity (stocking the required range and depth of items).

CURRENT MATERIEL SUPPLY SUPPORT

The priorities for materiel support provided to a maintenance depot are established by the Uniform Materiel Movement and Issue Priority System (UMMIPS). UMMIPS provides time standards for requisition processing and materiel movement by all activities of the DoD distribution and transportation systems. Priorities are based on the force activity designator (FAD) of the requesting organization and the urgency of need designator (UND) for the particular item. A maintenance depot typically has a FAD of 3, and thus, most depot requisitions have Priorities 3, 6, and 13, based on whether the UND is A, B, or C, respectively. These UMMIPS priorities (3, 6, and 13) have response times — the times to cover all activities from requisition submission to part receipt — of 8, 12, and 31 days, respectively, associated with them.

Some stocks of piece parts are maintained in a forward position adjacent to the repair shops for issuance when requested by a shop. For example, the DMSC is positioned at a forward location and maintains 30 days of supply for items having frequent use; in addition, another 60 days of supply are maintained in the distribution depot. For the Army, the Automatic Storage and Retrieval System keeps a 15-day supply of repair parts on hand for the shops. The ISA is authorized a 60-day level and a 30-day order-and-shipping time.

To minimize the delays for piece part deficiencies, Service or ICP policies require that piece parts be obtained for forecasted work in advance of the induction, and most ICPs state that these requirements will be based on experienced failure data. Each supply activity uses a Service-unique system to determine its requirements for piece parts. Piece parts required in the repair of a DLR are frequently projected based on a bill of materiel (BOM) and are included in the overall demand forecast developed for the asset. The BOM combines configuration data for a DLR and projects piece part usage based on historical consumption data. In addition to BOM projections, other piece part requirements are provided through a special program requirement (SPR) by the inventory manager responsible for the repairable item. Although DLA is working with the Services to improve the SPR process, SPRs cover only a limited portion of repair parts required.

Maintenance personnel frequently described materiel support for the DoD depot repair process as inadequate. Many problems observed in shop scheduling and control are related to the inability of the current system to guarantee a reasonable level of parts support. Extensive cannibalization of parts from items awaiting repair to complete repair of other inducted components provides ample evidence of the effects of poor materiel support. The current management information systems do not provide the necessary visibility and information to

support a structured analysis of existing support problems that could identify systemic contributing factors.

Measurement of Awaiting Parts Time

DEPOT LEVEL

Condition Code G, which is defined as the status of materiel requiring additional parts or components to complete repair, was established to record AWP time. It is applicable to incomplete items for which the required parts are being, or have been, requisitioned. Changing the condition code to G enables supply and maintenance to detect funded workload that is on hand but cannot be completed and identify requirements for expediting piece parts. The current DRC environment is influenced by the Services' inconsistent application of the DoD policy for excluding awaiting parts time from repair cycle computations.

Wide disparities exist in the Services' use of Condition Code G to record AWP, in their exclusion of AWP time from the actual maintenance shop time, in their accumulation of AWP, and in measurement of the effect of AWP. The Air Force normally processes condition code changes only for anticipated delays of 30 days or more. The Air Force uses Condition Code G to remove an item from maintenance, but it does not accumulate the AWP time (the Air Force uses maintenance shop standards and not actual times in its RCL). It uses the information to revise its production plans. The NADEPs change condition codes only for anticipated delays of 45 days or more and, to the extent that Condition Code G is used, the AWP time is excluded from the actual maintenance shop time used in the Navy's RCL. The Navy does measure and report that portion of the AWP time. The Army does not use Condition Code G to indicate AWP time and the total AWP time subsequent to the transfer to maintenance is reflected in the actual maintenance shop time in the Army's RCL. The most significant difference among the Services in applying the DoD definition of DRCT is their treatment of AWP time.

INSTALLATION LEVEL

A noteworthy and desirable contrast exists between the availability and management use of AWP data at the intermediate maintenance level and those at the depot level. Each of the three Services' intermediate-level maintenance systems can record by individual workorder the beginning and ending of awaiting parts delays (other delays and processing segments are also recorded). The recording of AWP begins immediately upon notification of the nonavailability of parts (no minimum forecasted delay). The records also display requisitions for parts and their status. Management reports summarize the delays caused by AWP and show the work "in process" by time periods and all delays.

EVALUATION

Parts Shortages and Awaiting Parts

SIZE OF THE PROBLEM

We were unable to comprehensively quantify the magnitude of AWP incidence and its duration because of the inconsistent use of Condition Code G and the lack of systems to collect and portray AWP time. However, we believe materiel support delays are substantial.

Figure 4-1 shows the experience of one ICP supported by six organic depot repair facilities. Units remaining in Condition Code G at the end of the fiscal year (as a percentage of the total quantity inducted during that year) ranged from 4.8 to 12.9 percent.

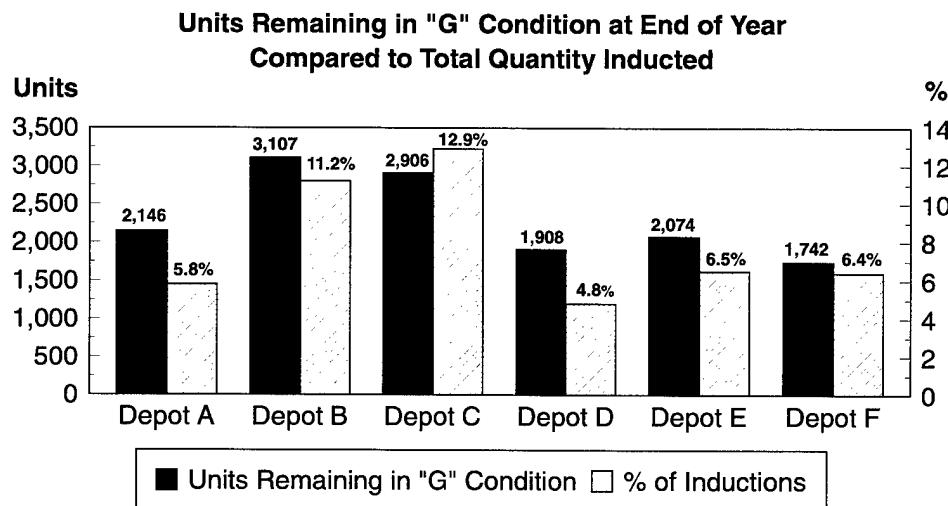


Figure 4-1.
Portion of Program Not Completed Due to Awaiting Parts

Another ICP reported that 4 percent or fewer of the items it managed would be in Condition Code G at any one time (although repair shops for its assets were observed to use Condition Code G infrequently to account for AWP time; therefore the AWP time is understated). Yet another ICP reported that the repair of 6.4 percent of its negotiated repair requirements for items in FY93 (over 6,500 units) had been delayed over 45 days because of the lack of repair parts, and these assets had been placed in Condition Code G. Furthermore, that experience does not include the AWP time for those items not transferred to Condition Code G.

At another ICP, parts-related delays accounted for 2.4 percent of those failures to meet repair schedules and was the largest single factor accounting for such delays. Those delays were to the negotiated program quantities, which had already been reduced from the total requirement because of known parts shortages at the time of negotiation.

At yet another organic depot maintenance activity, we obtained detailed information on a sample of 365 NSNs that were causing either work stoppage (323 NSNs) or workaround (42 NSNs) in two shops. Figure 4-2 displays the number of NSN units for each 30-day delay period as of the report date (we do not have information as to the subsequent additional delay). Approximately 75 percent of the NSN units experienced work stoppage or workaround of more than 30 days and up to 574 days as of the report cutoff. The shortage quantities ranged from 1 to 5,324 units.

As Figure 4-2 shows, the shortage of piece parts frequently delays the repair of higher value unserviceable components for as long as four to six quarters, and sometimes even longer. Awaiting parts histories of individual NSN units complete with requisition numbers, points of contact, contract numbers, and estimated delivery dates were available. Management reports reflecting the number of NSNs causing work stoppage, duration of shortage, and value of DLRs affected were almost nonexistent.

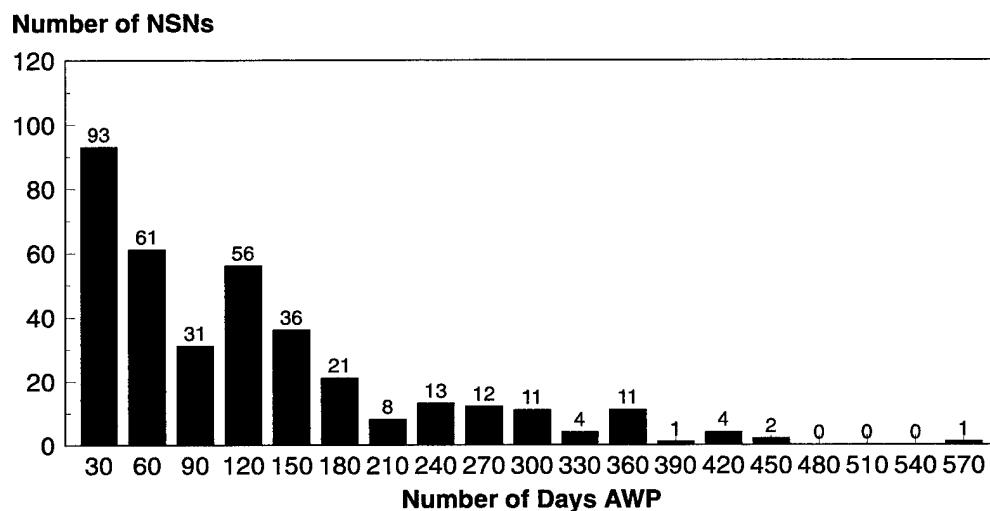


Figure 4-2.
NSNs Causing Work Stoppage or Workaround

IMPACT OF AWP

During our field visits, maintenance often cited the lack of repair parts as a cause of excessive repair cycle times for some components. Materiel shortages

that are discovered after the induction process has begun delay repair and have other direct effects that are discussed below. In addition, when materiel shortages exist, components are sometimes overinducted to "rob-back" parts. That practice not only masks materiel support deficiencies but also increases the obligation of repair funds. As units are cannibalized, they are held in Condition Code M as though they were actually being repaired to meet a valid wholesale system requirement (usually without the IM's awareness). The extended DRCT is included in the inventory management files of some Services and used in RCL computations, thereby increasing inventory investment.

The full extent to which AWP time remains a significant problem is difficult to quantify because of poor documentation. However, the frequent use of cannibalization and rob-back procedures increases scheduling workload and operating costs in addition to having other implications as discussed below.

Analyzing the effects of AWP time provides a meaningful benchmark to evaluate overall materiel support for depot component repair. An AWP condition occurs when an induction is delayed, induction quantities are reduced, or repair action is delayed because the parts needed to repair the assets scheduled for repair are not available. Failure to monitor the materiel support delays will negatively affect projected materiel availability from repair, which may, in turn, decrease the operational readiness of supported customers. Managers must focus clearly and directly on the materiel support being provided and must analyze the causes for any materiel delays. Thus, the measurement and analysis of AWP time are critical to an evaluation of materiel responsiveness and are an indication of the effectiveness of customer support.

Table 4-1 provides examples observed at a depot maintenance facility where piece parts with low unit prices were delaying the repair of high-value components. A ball bearing (the first item in Table 4-1) had caused a work stoppage on a cylinder assembly for over 440 days as of the report cutoff and was expected to increase. In fact, the total work stoppage quantity of the ball bearing was 279 units, resulting in the work stoppage on 70 cylinder assemblies. The unit price of the ball bearing was \$18.56 and the value of the 279 bearings was \$5,178 (or less than 2/10ths of one percent of the unit cost of the delayed DLRs). The unit price of the cylinder assembly was \$46,752 and the value of the 70 assemblies was \$3,272,640 or 632 times the value of the parts causing the work stoppage.

The sample items selected in Table 4-1 are managed by DLA. Although all of the items are required to repair helicopter DLRs, all are designated as non-essential in the DLA weapon systems file. Current management objectives need to be reoriented to recognize the imbalance in attention to piece-part shortages and the significant delays that low-value items can cause in the repair of high-value components. The essentiality of the repair parts must be conveyed from the DLR manager to the repair part manager.

Table 4-1.
*Sample List of Items Causing AWP Conditions at the Hydraulics Shop
of an Organic Maintenance Depot*

NSN	Item name	Unit price	Quantity causing work stoppage	Days work delayed (at time of review)
3110-01-133-9539	Ball bearing	\$18.56	279	443
1850-01-046-2256	Spool and sleeve	\$2,921.27	17	180
3110-00-197-2371	Ball bearing	17.46	30	180
5305-01-007-0948	Cap screw	23.7	120	117
5305-01-156-7672	Cap screw	26.98	150	91
5306-00-549-3433	Cap bolt	26.51	48	117
5340-01-134-2505	Plate clip	81.08	167	91
5360-01-130-7241	Compression spring	\$54.92	26	91
5365-01-216-7318	Sleeve spacer	54.91	13	91
5365-01-216-7322	Sleeve spacer	\$74.97	26	91

Inclusion or Exclusion of Awaiting Parts Time from DRCT

Whether and how AWP time is included in DRCT can directly affect the requirements determination process. If AWP time is included in repair cycle computations, it could be a large element of the repair time. The arguments for including and excluding AWP time in the DRCT and the computations of the RCL have been reviewed adequately by previous studies.

The main argument for including AWP time is that AWP time is not really "avoidable" but is an occurrence that needs to be recognized, and that the DRCTs used to compute the RCL should reflect reality. According to that reasoning, excluding AWP time generally degrades supply support since it understates the RCL, the wholesale inventory investment in reparables required to support the depot repair pipeline.

Our analysis indicates that the more compelling argument is to exclude AWP time for three reasons.

- ◆ Its inclusion increases the DRCT and thus generates the need to procure and hold additional reparables. The assets are usually much more expensive than the piece parts used to repair them. The most cost-effective way to reduce DRCT is to improve the availability of less-expensive piece parts.
- ◆ Empirical evidence indicates that the shortage of repair parts for specific reparables is random and irregular and, consequently, not in synchronization with the RCL requirements. The historic DRCT is determined after the reparables asset has completed the depot repair cycle and has been

returned to supply as ready for issue. By that time, the specific piece part shortage has usually been eliminated, since the asset has been repaired. However, at the time it is measured, if AWP time is included, the DRCT will show the need for additional assets. The additional assets will not likely be received by supply for approximately two years (the average lead-time). At that time, not only will the original parts shortage have been eliminated but the new assets may create an excess of materiel requirements.

- ◆ Inclusion of AWP time in the DRCT can divert management attention from the real problem: the lack of needed piece parts.

Automated Systems Support

The systems support for AWP management is generally deficient given the importance of timely materiel support for the DRC process, the need to expedite piece parts once their shortage is identified, and the opportunities offered by the continuing advances in automated information systems. Procedures for managing the AWP process are labor-intensive, often manual, and generally require excessive intervention between the item manager and the repair facility.

The most comprehensive system for managing AWP time we observed was a Condition Code G management program, nicknamed G-MAN, developed by the Naval Air Systems Command and the Navy Aviation Supply Office as an automated inventory control system to manage Condition Code G components and piece parts for naval aviation depot maintenance. It is a PC-based tool that tracks the status of Condition Code G assets and expedites the delivery of AWPs for the components being reworked by the NADEPs.

G-MAN establishes a Condition Code G record when a DLR is AWPs, generates bar-code labels to be used as the asset is being controlled by G-MAN, and records piece parts as they are received. It matches all piece parts with their DLR to constitute those ready for reinduction and provides for the reinduction of Condition Code G items when requested by the NADEP. It is also used to inventory the warehouse to ensure correct reporting of Condition Code G components and repair parts and the accuracy of the master stock item record. Although only implemented in 1993, it has significantly reduced manual accounting and record keeping. However, it is limited to those items that meet the criteria and are actually transferred to Condition Code G.

The other Services also have some systems supporting the recording and managing of AWP time. The Air Force measures Condition Code G time by D9 cards as they are entered into the D035K system. D035K provides a monthly listing of piece parts to be analyzed by the DMSC to improve supply support. For the Army, parts problems are documented in the Standard Depot System. Each item backordered is recorded with its estimated delivery date, but the system is not used to perform analyses.

However, many depot repair activities perform limited AWP management. Measurement of parts-related delays through the use of Condition Code G is inconsistent and, at best, encompasses only a portion of the problem. In many cases, the delay is not recorded as a separate element and is, therefore, rolled up in the actual DRCT experienced for the component. The limited management is symptomatic of the incomplete documentation and insufficient automated assistance to provide inventory control and tracking.

Conclusions

No single wholesale-level system is available to provide a comprehensive view of the frequency, duration, magnitude, or adverse impacts of AWP time on depot-level maintenance efficiency and costs, inventory investment, or customer support. Our observation and evaluation of current systems, operations, and data supplemented with additional data obtained from manual records leads us to the following conclusions:

- ◆ The total magnitude of the AWP problem is unknown because of its inconsistent and incomplete measurement. However considerable partial data indicate that it is a pervasive and serious problem.
- ◆ The exclusion of AWP time from the DRCT is a valid policy.
- ◆ AWP adversely affects the depot maintenance process, causing a loss of efficiency (because of workarounds and set-asides until missing parts arrive and the need to reschedule repair), increases costs, and delays customer support.
- ◆ The measurement of AWP, identification of parts problems, and generation of management reports are critical steps to efficient maintenance processing and timely repair.
 - ▶ Improvements in wholesale information systems are required if improvements in AWP management are to be made. Most depots have at best only a limited capability to pass AWP information between the separate systems used to manage the DRC process.
 - ▶ Intermediate-level systems provide models for accumulating total AWP and generating management reports.
- ◆ Managing items in an AWP status requires an automated process such as the Navy's G-MAN. However, since it is limited to those items that meet the Navy's criteria and are actually transferred to Condition Code G, it should be expanded.
- ◆ More-accurate parts-consumption data are needed. Depot systems must accurately maintain the configuration data used in the BOM process and

improvements must be made in simplifying the process for recording piece parts consumed in the repair process.

- ◆ Parts forecasts and supply support must be improved.
- ◆ Long-term disassembly of reparable assets whose unserviceable inventory exceeds the retention limit may be a possible source of critical parts. Excess carcasses represent an economical and timely source of parts. Separate disassembly workorders should be used.
- ◆ Short-term cannibalization should only be used as a last resort when extended delays are indicated and critical requirements exist and should be done under separate (not repair) workorders.

RECOMMENDATIONS FOR PROCESS IMPROVEMENTS

With as much as 12.9 percent of the negotiated repair program not completed because of AWP, with as much as 75 percent of the AWP items experiencing delays of 30 days to 574 days, and with \$5,178 worth of parts delaying the repair of \$3,272,640 worth of DLRs for more than 440 days, AWP time clearly has a major adverse impact on the repair process.

To minimize that impact, which includes rescheduling production, increased man-hours and costs, production inefficiencies, and delays in customer support, we recommend that the Deputy Under Secretary of Defense (Logistics) make following process improvements.

Awaiting Parts Time

- ◆ Continue to exclude AWP time as an authorized segment of the DRCT and as an element of the RCL.
- ◆ Require that all AWP time in excess of one day be captured and reported.
- ◆ Require depot systems to be capable of
 - ▶ measuring the incidence and duration of all AWP time at the line-item level;
 - ▶ providing that information to all cognizant activities in an automated manner;
 - ▶ aggregating all the delays caused by AWP as a measure of materiel support effectiveness, with appropriate reports to maintenance managers, cognizant DLR ICPs, repair parts IMMs, and supply support activities supporting organic depot maintenance;

- ▶ providing annual reports to OSD showing the frequency of delays and the duration and value of delayed production; and
- ▶ managing DLRs and associated parts while awaiting parts (as is done with the Navy's G-MAN).

Parts Requirement Forecast

- ◆ Make greater accuracy in forecasting requirements for piece parts a priority effort encompassing repair for stock, concurrent repair for overhaul, and inter-Service support.
- ▶ Improve the process of recording piece-part consumption and forecasting parts requirements, including the use of bill-of-materiel concepts to reduce the incidence of repair delays that result from materiel support deficiencies.
- ▶ Provide parts forecasts annually based on the consumption data and the production plan to the repair parts IMMs.
- ▶ Provide parts forecasts quarterly based on the current production plan to the activity providing supply support to depot maintenance.

Materiel Support

- ◆ Use disassembly of assets in long supply as a source of supply for difficult to obtain parts.
- ◆ Limit cannibalization to situations of extended delays and urgent requirements.
- ◆ Broaden policy direction to encourage an up-front investment in repair parts.
- ◆ Review and revise essentiality coding in consonance with the effect of AWP time on customer support for the DLR and depot maintenance efficiency.

Revised Forecast Methodology

- ◆ OSD should sponsor an initiative with the Services and DLA to jointly consider revising the methodology for computing depot maintenance requirements by
 - ▶ computing the total (repair for stock, concurrent overhaul, and inter-Service support, and FMS) depot maintenance requirements (organic

and contractor) separately from all other requirements for the same items;

- starting with a zero base, combining recurring and special program requirements into a single computation based on the production plans and bills of materiel (similar to initial issue clothing computations); and
- annually comparing parts consumption with the forecasts to determine forecasting effectiveness.

CHAPTER 5

Management Information Systems

INTRODUCTION

Our analysis indicates that major improvements in DRC management within DoD Components will require depot repair processes that are more integrated, more flexible, and more tightly controlled and monitored. Those improved depot repair processes, within which DRCT becomes a key performance variable, must be viewed in terms of maximizing the productivity of both repairable DLRs and repair capabilities to meet operational customer requirements. We must consider the cost to repair, the delivery times to the customer, and the investment cost of RFI assets held in inventory to support anticipated demand.

Some of the inefficiencies and nonresponsiveness of current DRC processes are the result of policy decisions coupled with critical differences in the management perspective and performance goals of supply and maintenance managers. However, at the ICP and at the repair depot, they are also due in part to the fundamental design and interface of key management information systems (MISs) used to control and monitor the process. The abilities to track DLRs through the repair process, to identify bottlenecks or unanticipated delays, to expedite the repair of selected line items, to compare actual DRCT to standard DRCT at the individual line-item level, and to analyze and account for differences are extremely limited. Often commercial repair information and processing status is even more limited.

Current information systems used to manage DRC will need to undergo major overhauls if the recommendations advanced in this report are to be implemented. In this chapter, we discuss the major changes needed in current DRC information systems to support and facilitate the process changes recommended.

These key information system requirements and the infrastructure required to implement the new processes being recommended fall into the following five major areas: repair programming and production planning, induction processing, maintenance shop engineered time standards, materiel management support systems, and DRC monitoring and performance measurement.

REPAIR PROGRAMMING AND PRODUCTION PLANNING

Evaluation

Current MIs are predicated on essentially stable repair programs and off-line manual coordination of repair requirements. Capacity requirements for repairing DLRs for stock for those generated, from planned depot overhaul, and for inter-Service support and FMS are usually computed independently even though the same depots repair all and many of the same parts are required. Systems are unable to convert repair requirements into maintenance capacity requirements automatically. Furthermore, the latest data are not always used for the entire repair program period, thus making outyear projections of limited value; production planning is frequently based on annual averages that do not adequately provide for fluctuations in requirements; and production planning systems do not provide parts consumption data inputs into the requirement computations the IMM uses to forecast repair part needs a procurement lead-time away, and the maintenance supply support activity needs to forecast those needs a requisition lead-time away.

Recommended Process Improvements

We recommend that the Deputy Under Secretary of Defense (Logistics) implement the following process improvements:

- ◆ Integrate the requirements for repairing DLRs for stock, those DLRs generated from planned depot overhaul (generally separate systems), and those required for inter-Service and FMS support into a total maintenance capacity requirement for repair programming and production planning.
- ◆ Determine by workstation the capabilities and unconstrained capacity and capability required to complete an agreed-upon variance above all production plans. Compare those program capacity requirements with the ones currently available and quantify shortages and excesses.
- ◆ Generate annual production plans with variable monthly requirements projected through the budget year and linked to the line-item stratification and the budget process (the annual production plan will generate input to the determination process for wholesale part requirements).
- ◆ Also generate production plans quarterly for the following quarter with monthly projections (the quarterly plan will be input to the parts determination process for the installation supply activities).
- ◆ Identify items with marginal supply of unserviceable assets and notify retail activities to automatically expedite the return of such items using express transportation (capability similar to the Air Force's Reparable Item Movement Control System [RIMCS]).

INDUCTION PROCESSING

Evaluation

Current DoD information systems for managing the actual induction process are labor intensive, often manual, and generally require excessive intervention and off-line processing among the ICP, storage depot, and maintenance depot.

The process starts when line-item repair workorders are generated for specific quantities by priority to be repaired by required dates; it proceeds through the establishment of due ins from maintenance, transmission of the order to maintenance, production scheduling, requests to storage for carcasses and their transfer to maintenance, requests to installation supply for parts and their transfer to maintenance, and the return of the repaired DLR to storage; and it ends with the recording of the serviceable asset as on hand. Many of these process steps require updates to the ICP records as well as the processing activities and the recording of the actual time to perform those actions that are segments of the DRC. Today, many of the actions are performed through the use of hard-copy documents, with more than one activity entering data to record the same event.

For emergency or expedited repair requirements, only a limited number of systems routinely allowed for "advanced induction scheduling" prior to receipt of the carcass at the storage depot, for the direct flow of retrograde into the maintenance depot (bypassing the storage depot take-up), or for direct issue of repaired RFI assets from the maintenance depot in emergency situations.

Recommended Process Improvements

We recommend that the Deputy Under Secretary of Defense (Logistics) implement the following process improvements:

- ◆ Generate repair workorders the repair turnaround time (based on standards) and the repair administrative lead-time (RALT) in advance of the required date based on the asset position at time the workorder is created, provide quantities by maintenance priority, and transmit workorders electronically directly to the maintenance depot.
- ◆ Increment "due in from maintenance" simultaneously with the generation of the repair workorder and decrement it when the materiel is received in maintenance (changed to Condition Code M).
- ◆ Minimize manual processing and multiple data entry by automating the interfaces among ICPs, depot maintenance, and distribution depots in processing repair workorders, requests for carcasses, and transfers between storage and maintenance and in recording condition code changes while

tracking workorders by unit quantities (establish a capability similar to that of the Navy's Bar-Coded Repairables Electronic Exchange System [BREES]).

- ◆ Have techniques similar to finite capacity scheduling and MRP II capability
 - to assess by workstation the unconstrained capacity and capability required to produce on time the requirements for DLRs as specified in the production plans for repair of stock, concurrent with overhaul, inter-Service support and FMS to determine how much overtime or extra-shifts effort are required or other alternatives to complete the total workload projection or what other alternatives are available to do so; and
 - to effectively and efficiently schedule frequent (biweekly or more often) and small-quantity repair workorders with varying priorities and short required dates.
- ◆ Develop the capability to issue unserviceable assets directly from the receiving floor to maintenance when carcasses are in short supply and to issue serviceable assets directly to customers to fill backorders (similar to the Air Force's Stock Control and Distribution System express table).

MAINTENANCE SHOP ENGINEERED TIME STANDARDS

Evaluation

The maintenance shop segment of the DRC — the time from the receipt in maintenance of an unserviceable DLR until that asset has been repaired and turned over to the distribution depot — differs from the standard labor hours used in setting maintenance charges. A major ingredient of the engineered maintenance shop standard is the labor-hour standard; in addition to the critical path hands-on time, it includes nonlabor time such as paint drying time, movement time from workstation to workstation, and reasonable queue time before and after each workstation.

Most interfaces with the standards are off-line, manual linkages. Further, current depot repair and ICP systems do not capture the requisite level of detail on actual repair histories (for each unit inducted) at the line-item level (by RTAT segment) to allow for the effective analysis and validation or updating of RTAT standards over time. Existing systems for the development, analysis, and revision of DRCT standards at the line-item level are not effectively interfaced with ICP and depot production control and scheduling systems.

Recommended Process Improvements

We recommend that the Deputy Under Secretary of Defense (Logistics) implement the following process improvements:

- ◆ Provide an automated maintenance shop time database by line item with the engineered standards for the maintenance shop segment of the DRC as well as the actual times (exclusive of unanticipated delay times).
- ◆ Automatically provide the appropriate ICPs with the standard and actual times for each unit of each repair workorder for inclusion in the total DRCT database.
- ◆ Compare standard and actual times (exclusive of unanticipated delays) and produce reports to assist in reviewing operations and standards.

MATERIEL MANAGEMENT SUPPORT SYSTEMS

Evaluation

Most of today's materiel management systems for support of the repair process were not designed specifically to deal with the maintenance depot environment or the unique nature of DLR repair. Piece parts consumption recording, actual forecasting of parts requirements using bill-of-material concepts, transmission and use of parts usage projections in wholesale inventory management, and retail supply stockage processing all must be improved to increase the validity of the requirements and reduce the incidence of repair delays that result from materiel support problems.

As in other areas, these improvements cross multiple processing systems (at the ICP, the maintenance depot, and the retail supply activity) and involve both improvement of internal system functionality and better linkages between systems for passing and using information. Specifically, parts requirements for repairing DLRs generated by depot overhauling and inter-Service support must be integrated with those for repairing DLRs for stock. Further, some changes are derivatives of basic policy changes recommended to improve materiel support.

Recommended Process Improvements

We recommend that the Deputy Under Secretary of Defense (Logistics) implement the following process improvements:

- ◆ Simplify the data-collection process and thereby facilitate the accurate recording of usage data by the technician at the depot to improve its validity and be capable of projecting bills of materiel for "deterministic demand"

using a combination of configuration data and past consumption data collected by the maintenance depot.

- ◆ At the ICP managing the DLR, compute total annual parts requirements – i.e., repair for stock, concurrent overhaul repair, inter Service support, and FMS – a procurement lead-time in advance by using the BOM and the annual production plan requirements and electronically transmit that information to the appropriate parts IMM. Also compute the quarterly parts requirements by month by using the BOM and the quarterly production plan requirements and transmit the results to the appropriate installation supply activity,
- ◆ Provide the ICP managing the DLR with the ability to compute annually the time-phased special program requirements (SPRs) a procurement lead-time in advance to transmit funded SPRs to the appropriate IMM and to provide quarterly SPRs to the appropriate ISA.
- ◆ Give installation supply systems the ability to tie the SPRs quantity explicitly to the depot maintenance drawdown and the IMM ICPs the ability to compare the SPRs with the requisitions against them (similar to the system DLA is currently developing).
- ◆ Develop a prototype system for the Services and DLA to test zero-based requirements using separate computations for depot maintenance activities. Use the annual production plan for the combined deterministic and SPR requirements (similar to the methodology used for induction center initial issue).
- ◆ Compare production plans and parts forecasts based on the BOM with the executed repair workorders and parts usage and generate appropriate management reports.

DRC MONITORING AND PERFORMANCE MEASUREMENT

Evaluation

Perhaps the major system deficiency related to current DRC management within DoD is the failure of current systems to capture actual DRCT performance by segment with the incidence and duration of delays. Its absence precludes the monitoring of actual DRCT performance relative to established performance goals or standards. The lack of data precludes using the DRCT performance at the maintenance depot as an evaluation factor in assessing the effectiveness and efficiency of overall maintenance management. Further, the systems do not record, and thereby distinguish between, unanticipated delays and DRC element delays. The Air Force and the Army either fail to collect actual DRCT or fail to update it for extended periods.

Almost without exception, supply and maintenance managers we interviewed indicated that DRC performance was not included in existing management information systems, that no goals were used to evaluate this performance, and that costs and capacity utilization drove much of the management thinking at the repair depot. In discussing current DRCT data, managers were often unable to explicitly account for the length of actual DRCT in excess of the standards. While repair cost was universally recognized as an important management indicator, we found limited appreciation for the effects on investment and readiness that could be sustained when the actual RTAT exceeded standards. Most maintenance production control systems simply did not routinely track components by work center, and those systems rarely accounted for the cause of specific delays.

Recommended Process Improvements

We recommend that the Deputy Under Secretary of Defense (Logistics) implement the following process improvements:

- ◆ Develop a capability for measuring the incidence and duration of actual delays (in hours or days) at the line-item level for carcasses, parts, and maintenance capacity; for being able to pass that information to the maintenance activity, cognizant ICPs (DLR and repair parts), and installation supply in an automated manner on a weekly basis; and for generating semiannual performance reports for OSD.
- ◆ At the DLR ICPs, determine (by type of delay) the mean unanticipated delay and the variance/standard deviation in unanticipated delay to develop an appropriate repair safety-level quantity for the item on a cyclical basis when wholesale levels are updated or recomputed.
- ◆ Provide the capability to record and analyze actual repair history data (exclusive of unanticipated delays) at the line-item level for both organic and contractor repair and to compare that information with DRCT standards on a routine basis by segment of DRC.
- ◆ Generate monthly management performance reports for DLR ICPs, depot maintenance, distribution depots, and logistics headquarters and semi-annual performance reports for OSD.

APPENDIX A

DETAILED DEPOT REPAIR CYCLE BUSINESS PRACTICE IMPROVEMENTS

INTRODUCTION

In the main text, we present an analysis of various aspects of the depot repair cycle (DRC) process. We also recommend a series of business practice improvements to enhance the process by minimizing the imbalance between the materiel that is in maintenance and the materiel that should be in maintenance, reducing inventory investment, improving the actual repair turn-around time (RTAT), and providing more responsive customer support. A number of those recommendations were phrased in broad terms. This appendix provides the specifics needed to implement the proposed process improvements.

The proposed improvements include revising the DRC segments and their definitions to provide the framework required to improve the workorder and induction process; a description of workorder generation and induction as a separate process decoupled from production planning; and a description of time standards for each of the DRC segments.

In addition to the specific process improvements, we selected 15 of the private sector's "best practices" used in rating the 25 finalists for selection of "America's 10 Best Plants" by *Industry Week* for 1994. We selected those practices germane to the DRC process. The description of the specific practice and the percentage of the companies that place major emphasis on that practice are shown. Many of the best practices relate to the areas of business practice improvement addressed in this report.

DEPOT REPAIR CYCLE SEGMENTS AND DEFINITIONS

Current Policies

To establish uniform elements for the management and measurement of the DRC, DoD has identified five discrete segments to be used in defining the DRC: retrograde, accumulation, transfer to maintenance, depot maintenance turn-around, and transfer from maintenance. Those may be defined as follows:

- ◆ *Retrograde* begins with the determination that a depot-level repairable (DLR) is beyond the repair capability of organizational-level and intermediate-level maintenance and continues until the asset has been shipped to a depot

(organic or contractor), received, and recorded as on hand on the inventory control point's (ICP's) record.

- ◆ *Accumulation* begins when the wholesale depot records the receipt of an unserviceable DLR and ends with the accumulation of the minimal authorized batch quantity.
- ◆ *Transfer to Maintenance* begins with the processing a change from Condition Code F to Condition Code M, continues through picking the materiel requested for induction, and ends with the receipt of the materiel in the maintenance activity. (This segment includes shipment from a depot to a contractor.)
- ◆ *Depot maintenance turnaround* begins when maintenance receives the unserviceable asset, continues while the item is being repaired, and ends when the availability of the serviceable item is formally reported to storage. (This segment does not include awaiting parts time.)
- ◆ *Transfer from maintenance* begins when maintenance reports the availability of the serviceable asset, continues during the return to storage, and ends when the ICP records the serviceable asset. (This segment includes shipment from a contractor to a depot but does not include the process of stowing.)

The major purpose of the DRC segments is to provide the basis for establishing a repair cycle level (RCL) requirement. The RCL is intended to provide serviceable assets to meet customer demands during the time from when the determination that a DLR asset is beyond the organizational-and intermediate-level maintenance capability until that assets is made serviceable and is available for issue on the ICP's record.

Proposed Repair Cycle Segments

DoD Materiel Management Regulation, DoD 4140.1-R, should be revised to incorporate the following changes in the DRC segment names and definitions. The bases for our proposals are the evaluation of the current segments presented in Chapter 2 and the proposed revisions to induction processing discussed in Chapter 3. All segments apply to organic and contractor depot maintenance (the time frames for some elements may differ). The *depot repair cycle* is composed of two segments: the *retrograde* segment (a collective term for the *base-processing* and *in-transit* segments) and the *repair turnaround* segment (a collective term for the *transfer-to-maintenance*, *maintenance shop*, and *transfer-from-maintenance* segments).

- ◆ The *depot repair cycle time (DRCT)* is expressed in three different ways: the sum of the time standards authorized for the DRC segments, the actual time taken to complete those segments, and the time reflected in the ICP file. The DRCT does not include unanticipated delays (AWP, AWM, or AWC).

- ◆ *Base-processing* segment begins with a determination that organizational-level and intermediate-level maintenance cannot repair the unserviceable DLR and reports that fact to supply; it ends when the asset is ready for shipment from the base and is turned over to transportation.
- ◆ *In-transit* segment begins when transportation receives the ready-for-shipment unserviceable DLR and ends when the distribution depot or contractor processes the receipt transaction and the unserviceable DLR is recorded on the records of the ICP.
- ◆ *Transfer-to-maintenance* segment begins with the change in condition code from I (see *due for induction* below) to M and ends when the maintenance activity (organic or contractor) receives the unserviceable DLR. Transfers from depots to contractor facilities include transportation time.
- ◆ *Maintenance shop* segment begins when maintenance receives the unserviceable DLR and ends when the availability of the serviceable DLR is formally reported to storage. (This segment does not include AWP or AWM time.)
- ◆ *Transfer-from-maintenance* segment begins when the maintenance activity formally reports the availability of the serviceable DLR and ends when the serviceable asset is received in storage and is recorded on the records of the ICP. It does not include stowing. If the serviceable asset is shipped directly to a customer from a contractor maintenance activity the segment ends with the formal notification. Transfers from contractors' facilities to depots include transportation; transfers to customers do not.
- ◆ *Repair workorder (RWO)* is a document with funding generated by the DLR inventory manager authorizing a depot maintenance activity to repair a specific quantity of an item. The RWO specifies the quantity by required delivery date (RDD) and the following maintenance priority: A = customer backorders; B = safety-level deficiencies; and C = balance of RCL deficit.
- ◆ *Repair workorder cycle (RWOC)* segment begins at the end of the repair turn-around time and continues to the end of the prescribed fixed-time cycle. The RWOC is the interval between orders, determines the frequency that work orders are generated, and permits the accumulation of unserviceable DLRs. The RWOC is a part of the DRC and the RCL, and is analogous to the procurement cycle.
- ◆ *Economic induction quantity (EIQ)* is the quantity determined by computing the break-even point between the costs of induction (the cost of storage picking and delivering the unserviceable assets to maintenance, the maintenance setup costs, and the lost production for fully utilized equipment) and the required increased investment (one-time cost of acquiring additional inventory and recurring holding costs including the cost of money). The EIQ is not included in either the DRC or RCL. It is used to compute the economic induction additive (EIA).

- ◆ *Economic induction additive* (EIA) is the positive quantity computed by subtracting the RWOC quantity from the EIQ. Normally the EIA will be zero. A quantity greater than zero is authorized only in those documented instances in which the more economical alternative is to induct an EIQ greater than the RWOC quantity. The EIA is not included in the DRC but the quantity, not time, is included in the RCL.

[Note: *Accumulation* segment is no longer required. It has been replaced by the RWOC quantity and the EIA quantity.]

- ◆ *Repair administrative lead-time* (RALT) begins with the asset cutoff for generating an organic depot or contractor repair order and continues until the beginning of the projected RTAT. The RALT is not part of the DRC and does not increase the RCL. It provides time to generate a funded repair workorder, transmit the order to the appropriate maintenance activity, schedule production, obtain repair parts from the installation supply support activity, forward an induction request to storage, and post the change from Condition Code I to Condition Code M to the ICP record (the beginning of the transfer-to-maintenance segment).
- ◆ *Repair cycle level* (RCL) is a collective term for the quantity derived from the DRC time multiplied by the net unserviceable return rate (returns less anticipated washouts) plus the EIA, if any.
- ◆ *Due for induction* is the quantity of an item placed on a funded RWO and not yet inducted into maintenance (condition code not changed to M). The due for induction is incremented by a change in Condition Code F to Condition Code I for the quantity on an RWO at the time of its generation and decremented by the change from Condition Code I to Condition Code M for a quantity on that same workorder. Due-for-induction assets reflected in Condition Code I will be treated like Condition Code M assets to preclude these quantities that have not yet been inducted from duplication on subsequent repair work orders.
- ◆ *Condition Code I, Suspended, Pending Induction into Maintenance*, is recommended for inclusion in manual DoD 4000.25-2M, *Military Standard Transaction Accounting and Reporting Procedures*, to provide for materiel scheduled on a funded RWO but not yet inducted into maintenance (Condition Code I materiel and Condition Code G materiel should be reflected in the Unserviceable – Scheduled column of the Central Secondary Item Stratification Report). In addition to providing for establishment of “due for induction,” it will permit measurement of induction time.

INDUCTION PROCESS IMPROVEMENTS

Coordinated quarterly production planning volumes or targets with an agreed-upon quantity plus a variance would continue to represent the planned commitment by the maintenance depot to produce. The specific timing of repair

inductions during the quarter and the quantities of assets inducted and repaired in a given lot (critical to responsive customer support and to DRCT investment) are the purview of the wholesale inventory manager. The RWO should be initiated by the IM within the constraints of the planned production target without further coordination. Moreover, repair funding authorized (and obligated) should be tied not to the production planning targets but rather to specific repair authorizations issued for each repair order by the IM. Finally, each specific repair induction should be based on a prioritized induction or repair authorization (the equivalent of customer orders in the private sector) that would allow the maintenance depot to focus repair capabilities on the most critical items.

Thus, based on our assessment of current DoD induction processing policies and systems, we recommend that the wholesale IMM be responsible for determining specific a workorder (quantity and timing) and that the IMM generate a specific repair request/workorder each plus the standard RTAT in advance of the RDD. Given the proposed RALT of 14 days, repair work orders (with associated repair funding for the specific repair order quantity only) should be received by the maintenance depot for processing 10 days prior to the commencement of the RTAT for the order. That procedure would give the maintenance depot time to schedule induction, to request the not ready for issue (NRFI) carcasses, and to receive and process the carcasses.

Over time and with improvement in processing efficiencies, a further reduction in the length of the RWOC should be sought. By constraining RWO authorizations to 14 days, an average of approximately three lots would be in repair (steady-state projection) at any point in time (using proposed DRCT standards) for a given item, a level we believe is workable in today's system.

Key elements of the induction processing improvements are described in the following paragraphs:

- ◆ RWOs are generated not less frequently than biweekly for a specific NSN item and maintenance facility based on the asset position as of the cutoff date. The wholesale manager obligates and funds the orders and transmits them electronically to arrive at the appropriate depot maintenance facility by the specified time (part of the RALT). The maintenance activity has the balance of the RALT to schedule production and request the storage activity to deliver the unserviceable assets and parts. Maintenance determines the number of lots, their size, and their timing for induction (not to exceed the repair workorder quantity [RWOQ] but in time to meet the RDDs). Induction lots should not exceed the EIQ. However, when less than the full EIQ of unserviceable assets is available to meet Maintenance Priorities A and B, the less- than-EIQ quantity will be inducted.
- ◆ The RWOQ is the quantity of assets required to bring the sum of Condition Codes A, B, G, and M assets and those assets due for induction (less the net unserviceable returns during the RALT) into balance with the requirement levels through the RCL.

$RWOQ + PPWR-P + OWRR-P + DUE OUT + SL + NSO + RCL - [(Condition Codes A, B, G, and M assets and due for induction) - (average net unservicable return rate \times RALT)].$

- ◆ Due for induction will be incremented by the generation of the RWOQ and decremented by the change from Condition Code F to M.
- ◆ The RWOQ is subdivided into three priorities — Maintenance Priority A, that quantity required to satisfy customer backorders; Maintenance Priority B, that quantity required to satisfy safety-level deficiencies; and Maintenance Priority C, that quantity required to satisfy the balance of the RCL deficit.
- ◆ The RWOs contain an RDD at which time the last of the workorder quantity is returned to storage and recorded as serviceable on the records of the ICP. Incremental deliveries should be made prior to the RDD but not less frequently than weekly and as soon as repaired for Maintenance Priority A assets.
- ◆ Maintenance activities are not authorized to induct quantities for repair greater than the sum of the funded orders.

Figure A-1 depicts the revised workorder generation and induction processing.

REVISED RALT, RWOC, INDUCTION, AND DELIVERY CONCEPT

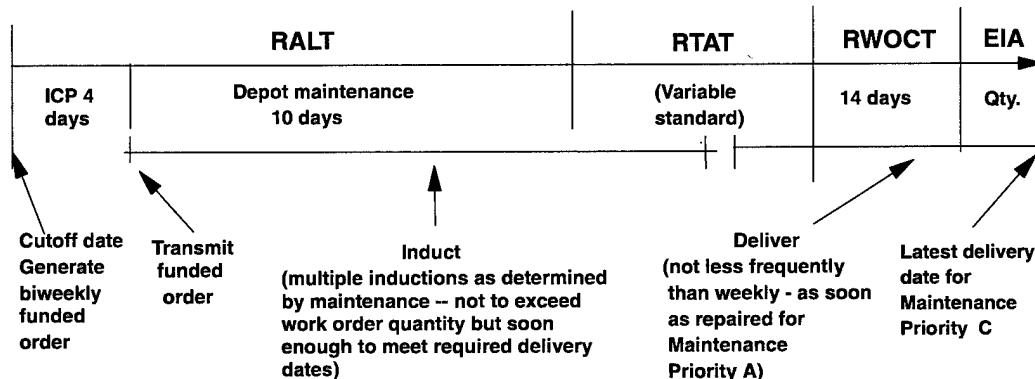


Figure A-1.
Revised Repair Work Order Processing with RALT and RWOC

We believe that collectively the changes recommended in induction processing, including funding, will substantially reduce actual DRCT, will cut RCL inventory/investment requirements, minimize the imbalance of over-and under-induction, and will materially increase the flexibility and responsiveness of today's component repair process.

DRCT STANDARDS

To adequately — but not excessively — compensate for the critical path period of time necessary to repair unserviceable assets, the Services must invest in replacement assets. Since the amount of that investment is a direct function of DRCT, DoD should establish reasonable "should-take" time standards as processing time goals for each segment of the DRCT as proposed in Table A-1.

Table A-1.
Proposed DRCT Standards by Segment (In Calendar Days)

Segment	Proposed standard/allowance	Method/approach
Retrograde Base processing	Base processing plus in transit 4-day maximum	Observations exceeding the ^a following limits by UMMIPS areas are excluded: CONUS > 12; Area 1 > 40; Area 2 > 45; Area 3 > 55; and Area 4 > 73.
In transit (includes receipt processing)	Constrained actual weighted average maximum	
Repair turnaround time Transfer-to-maintenance Maintenance shop Transfer-from-maintenance	2 days for organic and 10 days for contractor maximum Three types of industrial engineer standards 2 days for organic and 10 days for contractor maximum	Excludes unanticipated delays Total observations, sample observations, similar items with allowances for movement and queue converted to calendar days Includes receipt processing
Repair work order cycle time	Maximum of 14 days	
Economic induction additive	No fixed quantity — not included in DRCT	EIQ minus RWOC quantity (included in RCL)
Repair administrative lead-time	14 days from asset cutoff to RTAT (5 days to ICP transmittal and 9 days maintenance)	Not included in DRCT or RCL

^aThese times will require revision on the basis of the changes made to UMMIPS by the Logistics Response Time process action team.

Standards should be established for two key reasons. First, a reduced RCL requirement, based on valid standard DRCT, will substantially reduce budget requirements and, over time, will require a much smaller investment in inventory assets. Based on our line-item sample, the opportunity for reducing RCL requirements by applying valid DRCT standards is significant. Second, use of DRCT segment standards permits managers to optimally use their resources by providing them with a tool to measure the performance of the depot repair process (by segment) and to take remedial management action required to improve this performance.

We recommend that the Deputy Under Secretary of Defense (Logistics) make the following process changes:

- ◆ Adopt the proposed DRCT standards shown in Table A-1. Use of these standards as valid benchmarks in requirements computation, budgeting, and repair execution would focus both supply and maintenance management attention on DRCT. Thus, the cost and ultimate support effectiveness of the depot repair process will be directly driven by the validity and use/adherence to these standards.
- ◆ Use a mix of engineered time standards, work sample standards, and technical standards for the maintenance shop time segment.

BEST PRACTICES OF AMERICA'S BEST PLANTS

Annually, *Industry Week* has a panel of judges select "America's 10 best industrial plants." The following "best practices" were selected as being germane to the DRC process. Each percentage represents the portion of the 25 finalists that place major emphasis on the best practice. In addition to the list of the best practices are inventory management and manufacturing operations improvements and the definitions of the best practices.

Best Practices

<u>Best Practice</u>	<u>Percentage</u>
Total quality management	96
Cycle-time reduction	96
JIT/continuous-flow manufacturing	96
Cellular production	80
Employee cross-training	100
Use of cross-functional teams	100
Performance measurement	100
Inventory reduction	100
Delivery dependability	100
Reducing order-to-shipment lead-time	100
Agile manufacturing strategies	80

<u>Best Practice</u>	<u>Percentage</u>
MRP II	80
Finite capacity scheduling	56
Bar coding	88
Shop-floor data collection systems	88

Inventory Management

	<u>High</u>	<u>Low</u>	<u>Avg.</u>	<u>Median</u>
Annual inventory turns	78	3.6	14.8	7.0
Annual work-in-process (WIP) turns	817	4.2	103.7	42.6
Total inventory reduction in 5 years	82%	0%	38.0%	41.0%
WIP inventory reduction in 5 years	99%	0%	51.6%	50.0%

Manufacturing Operations

	<u>High</u>	<u>Low</u>	<u>Avg.</u>	<u>Median</u>
Reduction in component lot sizes	97%	16%	65.9%	75.0%
Reduction in cycle time within last 5 years	98%	10%	49.7%	50.0%
On-time delivery rate	100%	88%	97.6%	99.0%

Definitions

Agile manufacturing — In essence, it is the ability to thrive under conditions of constant and unpredictable change. Like flexible manufacturing, agile manufacturing, seeks to achieve rapid response to customer needs. But agile manufacturing also emphasizes the ability to quickly reconfigure operations — and strategic alliances — to respond rapidly to dynamic shifts in the marketplace.

Cellular manufacturing — A manufacturing approach in which equipment and workstations are arranged to facilitate small-lot, continuous-flow production. In a manufacturing “cell,” all operations necessary to produce a component or subassembly are performed in close proximity, thus allowing for quick feedback between operators. Workers in a manufacturing cell are typically cross-trained and, hence able to perform multiple tasks, as needed.

Employee cross-training — Skill-development practices that require or encourage production workers and other employees to master multiple job skills, thus enhancing work force flexibility.

Finite capacity scheduling — Software-based systems that enable simulation of production scheduling (and determination of delivery dates) based on actual unit/hour capacity at each step in the production routing. Finite scheduling systems, running on desktop computers, often compensate for the “infinite capacity” assumptions built into capacity-planning modules in traditional MRP II systems.

JIT/continuous-flow production — Implementation of “just-in-time” techniques to reduce lot sizes, reduce setup times, slash work-in-process inventory, reduce waste, minimize non-value-added activities, improve throughput, and reduce manufacturing cycle time. JIT production typically involves use of “pull” signals to initiate production activity, in contrast to workorder (“push”) systems in which production scheduling typically is based on forecasted demand rather than actual orders. In many “pull” systems, a customer order/shipment date triggers final assembly, which in turn forces replenishment of component WIP inventory at upstream stages of production.

Manufacturing cycle time — The length of time from the start of production and assembly operations for a particular (finished) product to the completion of all manufacturing, assembly, and testing for that product or specific customer order. (Does not include front-end order-entry time or engineering time spent on customized configuration of nonstandard items.)

MRP II — Software-based Manufacturing Resources Planning I systems that translate forecasts into master production schedules, maintain bills of material (BOM's) lists of product components), create work orders for each step in production routing, track inventory levels, coordinate materials purchases with production requirements, generate “exception” reports identifying expected material shortages or other potential production problems, record shop floor data, collect data for financial reporting purposes, and other tasks depending on the configuration of the MRP II package.

Shop floor data collection — Automated collection of data on factory production activities, including units produced, labor-hours per unit or customer order, time and date of specific production activities, and maintenance and quality data.

Total quality management (TQM) — A multifaceted, company-wide approach to improving all aspects of quality and customer satisfaction — including fast response and service, as well as product quality.

Work-in-process inventory (WIP) — The amount or value of all materials, components, and subassemblies representing partially completed production; anything between the raw material/purchased component state and finished-goods stage. Value should be calculated at plant cost, including material, direct labor, and overhead.

WIP turns — The value of total annual shipments at plant cost (for the most recent full year) divided by the current WIP value at plant cost.

APPENDIX B

Glossary

AWC	= awaiting carcasses
AWM	= awaiting maintenance
AWP	= awaiting parts
BES	= Budget Estimate Submission
BOM	= bill of materiel
BREES	= Bar-Coded Repairables Electronic Exchange System
CSIS	= Central Secondary Item Stratification
DLR	= depot level reparable
DMSC	= Depot Maintenance Support Center
DRC	= depot repair cycle
DRCT	= depot repair cycle time
EIA	= economic induction additive
EIQ	= economic induction quantity
FAD	= force activity designator
FISC	= Fleet and Industrial Supply Center
FTE	= Customer Excess Report
FTR	= Reply to Customer Excess Report
ICP	= inventory control point
IM	= inventory manager
IMM	= integrated materiel manager
ISA	= Installation Supply Activity

JIT	= just in time
JLSC	= Joint Logistics Systems Center
LMI	= Logistics Management Institute
MIS	= management information system
MRP II	= Manufacturing Resources Planning II
NADEP	= Naval Aviation Depot
NRFI	= not ready for issue
NSN	= national stock number
NSO	= numeric stockage objective
PC	= personal computer
RALT	= repair administrative lead-time
RCL	= repair cycle level
RDD	= required delivery date
RFI	= ready for issue
RIMCS	= Reparable Item Movement Control System
RO	= requirement objective
RTAT	= repair turn around time
RWO	= repair work order
RWOC	= repair work order cycle
RWOQ	= repair work order quantity
SPR	= special program requirement
UMMIPS	= Uniform Materiel Movement and Issue Priority System
UND	= urgency of need designator
WIP	= work in process

REPORT DOCUMENTATION PAGE

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